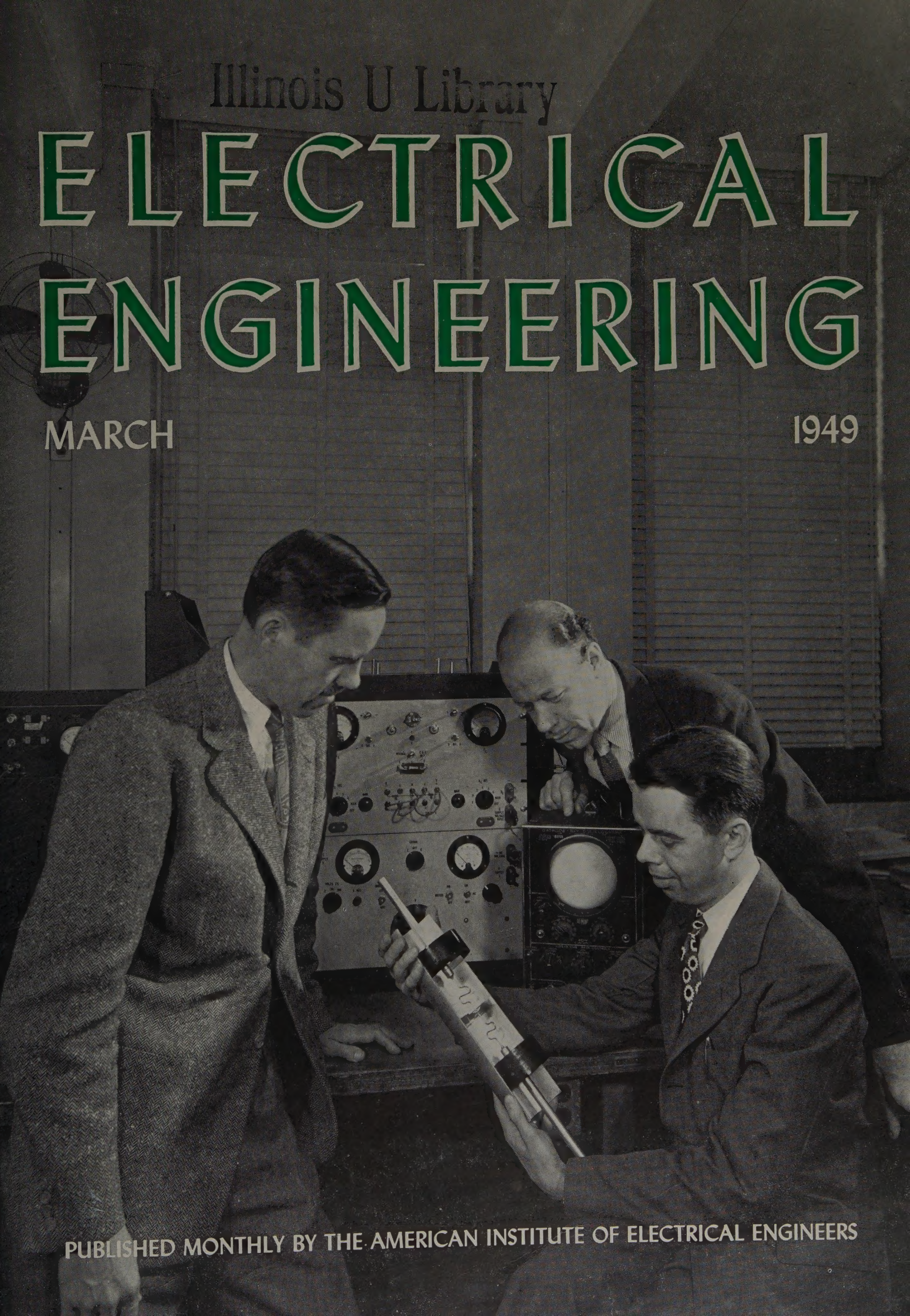
ELECTRICAL ENGINEERING

MARCH 1949



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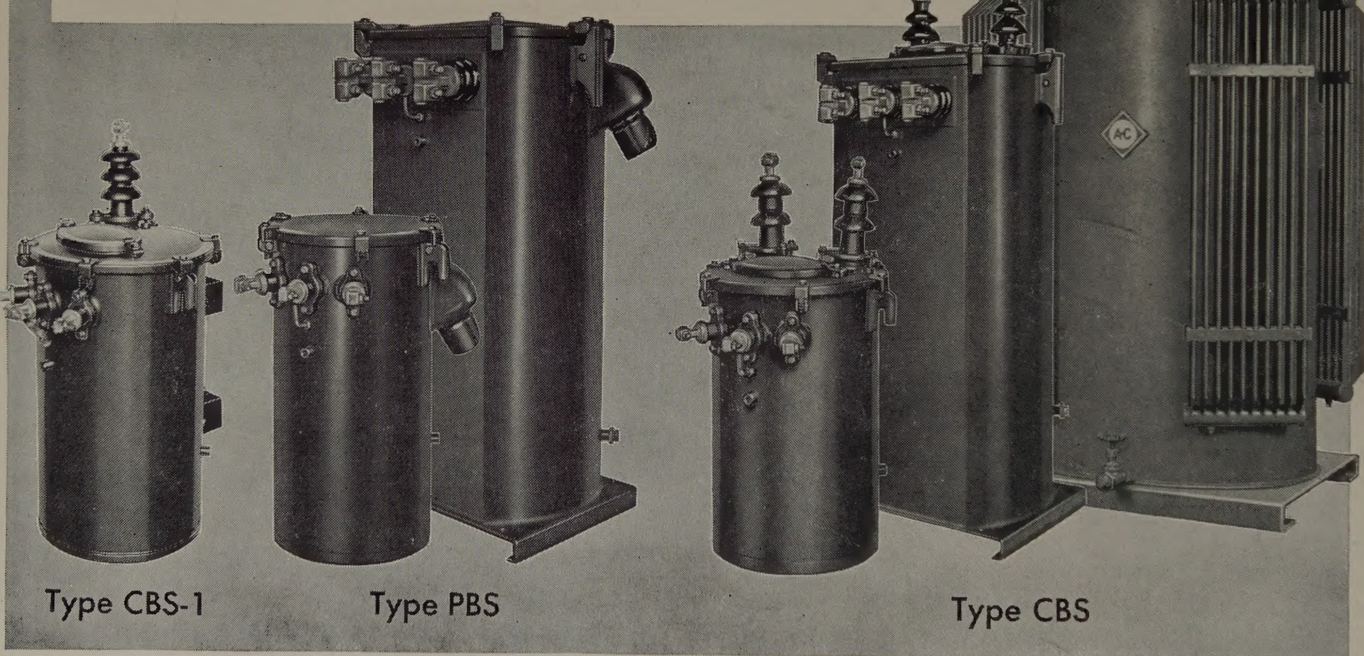

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The Professional Estate

CHARLES E. WILSON

General Electric's President Wilson takes his cue from Emerson's essay, "The American Scholar," in this article in which he points out to the engineer his responsibility, as a thinking man, to the society in which he lives. The professional man cannot, in good conscience, confine himself within the limits of his own technical sphere; he must learn to phrase his ideas in terms of the world.

ALMOST one hundred and twelve years ago a distinguished and well-known New England man of letters arose to address the Phi Beta Kappa Society at its annual meeting in Cambridge, Mass. His subject was the same one which was assigned to a speaker on that occasion year after year, but he made it indelibly his own, and it has survived the century and more to become a familiar piece of required reading in almost every high school and college English class. I am not familiar with the elements of the literary diet which is force-fed to budding engineers as a cultural offset to their grimmer subjects, but I would be a little surprised if most of them could not identify the speaker as Ralph Waldo Emerson, and his subject as "The American Scholar."

Engineers quite often assemble in groups to examine their problems, but only rarely, it seems, do they stand off as individuals and examine themselves and their relation to society. This is a usual characteristic of specialists. The scholar was such a specialist in 1837, and he still is one today, of course, but then he stood almost alone upon the American scene as the prime example of the professional man. Undoubtedly the Phi Beta Kappa Society, with its roster of ministers, lawyers, doctors, and teachers, pretty obviously represented not only the most concentrated scholarship of its day on this side of the Atlantic—the elite among literate men—but it also stood for something else. It stood for the aggressive and important forces in American life which then had attained the greatest development, and which were most respected and admired. Because this was so, Emerson set himself a task which seemed to him most important. Gently but firmly, with the welfare of the infant United States uppermost in his mind, he sought to lift the nose of the American scholar out of the book in which it was buried and point it into the wind, so that it might sense more truly what was going on in the world. What you have done is good and important, he said in effect, but you must be the master and not the servant of your knowledge. It is not enough to turn forever inward and become nothing but a specialist. You are a part of society as a whole; you have duties and obligations as well as privileges and distinctions.

THE ENGINEER'S POSITION

There is a curious and authentic similarity between the position of the American scholar in 1837 and the position of the engineer and physical scientist in 1949. It is not straining at the truth to say that the Institute, and its companion societies of the engineering and scientific world, bear the same relation to highly mechanized modern life which the organized scholars of Emerson's day bore to the more pastoral American scene of which they were a part. It would be foolish to attempt to evaluate the relative importance of the doctor, the lawyer, the economist, the teacher, and the engineer—to name just a few—in our present scheme of things. That is not necessary to make the point. All of us have our work cut out for us, and it is specialized and important work in a highly specialized world, at a critical stage in the development of civilization. But certainly the one overwhelming characteristic of this modern world is its tremendous material achievement and its vital dependence upon technology and science.

Our politics are shaped by our economics, and our economics are but the swiftly passing reflection of the scientific and technological progress of man. We have been caught up, in this century, in a whirlwind of new knowledge and the application of that knowledge, and it has left us breathless and trembling. With the dropping of the atomic bomb, we were shocked suddenly into a realization, an awesome realization, that our human capacity for intense specialization had gotten tragically ahead of our human capacity for thoughtful adjustment. For a time we seemed to hang in terrible and chaotic suspense over a yawning abyss of our own making, without knowing just what to do about it. Hiroshima was, in a sense, the final and rather staggering piece of evidence to prove, if more proof were needed, that the engineer-scientist today stands squarely in the center of the stage. He is that member of the professional estate most responsible for the nature of the world in which we all live. He has achieved distinction in the practice of his specialty, just as the New England scholars did in theirs. And like the scholars, he must solemnly consider his duties and obligations to society.

MAN'S RESPONSIBILITIES

Emerson introduced an ancient fable, that the gods in the beginning had divided *Man* into *men*, in order that he might be more helpful to himself. He was extremely critical of the fact that Man had become so metamorphosed into a thing, that he had become so engrossed in his specialization as a farmer or a professor or an engineer, that he had lost sight of the fact that in the beginning he was universal Man,

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Full text of an address presented at a general session of the AIEE winter general meeting, New York, N. Y., January 31–February 4, 1949.

Charles E. Wilson is president, General Electric Company, Schenectady, N. Y.

the original fountain of power. "You must take the whole society to find the whole man," he said, so subdivided and distributed has he become, and with increasing specialization this becomes harder and harder to do. His final point was this—that it was the duty of thinking men, and particularly of the scholar, as the foremost professionl man of his age, to leave off being a mere bookworm and lead the way back to a balanced and integrated society. If it is true, as I think, that the engineer-scientist is the foremost professional man of this age, then do not you, the reader, as an engineer, also have the obligation and the duty, as an individual and as a member of an association such as the AIEE, to give some thought to playing a similar role for the age which you have created?

These thoughts may seem rather abstruse, in marked contrast to the things that are considered in the usual technical papers and discussions. It is one of these strange quirks of human nature that most men are not at all embarrassed or reluctant to discuss with their fellows the day-to-day technical and professional problems on which they are engaged, but the more their minds run to shop talk on any plane, the more tongue-tied and thought-tied they become when a general question of morals or human behavior is posed. And yet these are very simple matters. The American Medical Association, the Society for the Advancement of Science, or the AIEE do not and cannot operate in the rare atmosphere of science and technology alone. Once they could, perhaps, but not today. Their members are not machines but men. By banding together they have become greater, and the sum is more significant then the parts. Through association, engineers have increased their professional stature and taken upon themselves, perhaps unconsciously, the duty to support and strengthen the society of which they are a part. You, as engineers, are bound henceforth not only to understand the technological progress which you are achieving in your specific ways, but you must understand the kind of society which supports that progress and, in turn, is borne forward on its shoulders.

Charles E. Wilson

I suspect that engineers underestimate their influence, as professional men. It is my impression that people in general are more likely to trust and admire an engineer or a scientist than they are a lawyer, or a teacher, or a soldier, or certainly a businessman. Perhaps the reason is that this attitude towards engineers is symbolic. There is probably a psychological explanation for it, but by and large engineers enjoy a wholesome status in the public mind similar to that enjoyed by a policeman or a big brother in the mind of a small boy. It stems from your concern with progress, from the fact that you work with materials and build things, and are at least theoretically untainted by having to deal with petty human concerns. If this does not jibe with your personal experience, please remember that I am giving you only the very general view from a lot of very small and uninformed birds. For all that, it should not be discounted.

Another explanation of your high station in the eyes of the common man lies in the fact that he does not understand what you are doing. One of my associates, in addressing a group of scientists the other day, said:

> What takes the heart out of the average man when he is confronted with atomic theory is the sneaking suspicion that he never got around to understanding relativity, as of approximately the year 1925, or the quantum theory, of about 1900. We subconsciously yearn for all the complex machinery that serves us so well in our daily lives, without the complex problems that attend them. We all secretly long for a log cabin on a mountainside—with a 2-lane concrete highway to, or almost to, our door; with air conditioning and television, and an electric kitchen, but with none of the troubles that attend a society which has those facilities.

THE ENGINEER IN SOCIETY

So much for some of the illogical but powerful reasons why you are highly regarded by the nonprofessional class. What are you doing to deserve this regard, not as bridge-builders and physical scientists, not as experts on distribution transformer and secondary conductor economics, but as *social* and *moral* scientists and engineers?

You must find, I am sure, as you consider these questions of your professional stewardship, that it is no longer possible for you just to confine your efforts to electrical engineering. In this respect, I am reminded of a statement made in 1922 by Charles A. Coffin, founder of the General Electric Company. He was then in his 78th year, and was speaking to a reporter from the *New York World* in one of the very few interviews he ever granted. He said:

> When we set up our research laboratory, we couldn't confine the research to commercial purposes. We gathered together the greatest scientists we could find. We equipped them with everything they needed to carry on their experiments. Not that we were better people than others, but because of the peculiar forces with which we were dealing, we soon found that we could not limit such an organization to the aim of making money.

The peculiar forces with which you, as engineers, are dealing today likewise will make it extremely difficult for

you to limit yourselves, in this modern world, to those matters ordinarily listed as the *PROCEEDINGS* and *TRANSACTIONS* of the Institute. You have come too far, you and those who preceded you, and you have powerfully affected and shaped the lives and destinies of too many millions of people, to deny your responsibility now. Brick by brick, step by step, computation by computation, you have with your own hands and brains built a great structure and equipped it with the machines and devices which have made American living and working standards the highest in the world. Our economic strength, our productive efficiency of which we are rightly proud, our free competitive markets, our enviable industrial machine, the abundance of our harvests, our leadership in research and technological achievement—in fact, every element of our fabulous enterprise system—bears the proud imprint of the engineering profession. So intensely have you concentrated on your specific tasks that you probably have not been aware of the magnitude of the whole job, or your own intimate connection with it.

Then what are the things that we ordinary citizens expect you engineers to do that you have not done before? What is it that we now feel we have a right to expect from your professional estate? The very same things that Emerson demanded from the American scholar more than a century ago; understanding and action. In your preoccupation with your sliderule you cannot safely leave to others, to the economists and politicians and lobbyists, the larger job of defending the way of life which was made possible by your own contributions. You have no right to delegate the duties of citizenship simply because you have a test to run, or a specification to write. You have no right to turn away from such problems as education, taxation, government reorganization, national security, civil rights, labor and management, or atomic power development, simply because they may involve you in controversy and take your time. It is quite true, of course, that no man today has the right to turn his back upon these things, but the professional man has a particular obligation to society, to understand and to act.

I have heard of an interesting doctrine in our common law which excellently illustrates the nature of this obligation. The lawyers call it the doctrine of lateral support, and it arises out of this set of circumstances. A man who owns a piece of land free and clear has the right to do with it as he wishes. If he wants to dig a hole or excavation that will extend all the way from his property line on one side to the property line on the other side, he may do so; that is his privilege and his right, and his neighbor cannot lawfully complain. But if, as a result of such an excavation, the land on his neighbor's side of the line begins to crumble and fall away, the man who dug the hole on his own property is liable for the damage. In other words, every landowner has the right to rely upon his neighbor for the support of his own land.

All of us are landowners in the community of our fellowmen. What we do on our own piece of ground to maintain our livelihood and pursue happiness is our own business. We can be printers or acrobats or engineers because that is our right as free men, and we cannot complain if our neighbors on either side ply their trade as shoemakers or farmers or automobile salesmen. But we plainly enjoy our rights at the price of an obligation; the obligation to insure the stability and safety of that community through intelligent conduct of our own affairs. That in turn results in our having an additional right, of course, the right to rely upon our neighbor for support and understanding. Thus does the law reflect an even more ancient law, the golden rule of human conduct.

POLITICS AND ENGINEERING

The day is indeed past when the professional man could delegate his understanding and his action, in a sphere not specially his own, to some selected advocate, or else neglect it altogether. For example, political theory and engineering still strike most of us as strange bedfellows, yet it is now apparent that a little preparation in the writings of Karl Marx and the Communist Manifesto would not have been an entirely useless provision in the technical curriculum. When communism jumps at you out of every headline and from around every familiar corner, the situation of even the average man becomes a little uncomfortable, and that of the professional man may be particularly difficult.

Since it is clear that officially, openly, and aggressively, the Communist party has the intention, and certainly the hope, of destroying the American system as it now exists, we no longer need concern ourselves with doubts on this score. The issues are plain, the stakes are high, and at long last even the degree of our danger seems to be apparent. What vexes and annoys most Americans today is largely the question of *who* are the communists, not *what* are they. And that is where the discomfort occurs. So ingrained in each of us are the convictions that civil liberties are worth preserving, that an individual is innocent and deserving of protection until proved guilty beyond the shadow of a doubt, and that hysterical red-baiting is undignified and shameful, that we spend our days torn between indignation and misgivings, and most often just wind up confused but uneasy. Here again there must be a great temptation for a true specialist, such as an engineer or a scientist, to withdraw into the protective and respectable cocoon of his immediate task and leave to others so inclined the vigilant defense of the republic. Yet to do so is to assume the spurious mantle of a protected class. At this point again, our witness is Emerson:

> Fear is a thing which a scholar by his very function puts behind him. Fear always springs from ignorance. . . . It is a shame to him if his tranquillity, amid dangerous times, arises from the presumption that his is a protected class.

The true professional man, if he values his integrity, will not compromise such an issue. He cannot, it seems to me, if he wants to keep his self-respect. I have one such example to cite.

A short time ago, in Seattle, Wash., six professors at the University of Washington, all with tenure rights, were tried before the regents of the university in regard to their relations with the Communist party. Three of them were dismissed. Watching this sober, strange, and rather tense spectacle were all kinds of Americans, like ourselves, torn

between the issue of the defense of academic freedom and the issue of the defense of our political and economic institutions. The issues were complex, as is always the case in such affairs, but the procedure was orderly in the extreme. In reading the newspaper accounts you quickly get the impression that all concerned were anxious to preserve both the spirit of justice and their own integrity, but that they were no less anxious to defend their country. Two of the professors admitted their membership in the party, and a third gave equivocal answers. On the clear note that this was to be no witch hunt, the trial proceeded.

It was made plain that nobody was going to be dismissed for his private beliefs, and those who sat in judgment had this burden: since the party itself is not illegal, they had to show that what is permitted in politics is not permissible in education. Both sides were in favor of academic freedom; but they had to decide what it meant. In one of the finest examples I have so far seen of an earnest, honest, and satisfying statement, President Raymond B. Allen of the university said:

> That academic freedom must be maintained in any university worthy of the name is beyond question. But academic freedom consists of something more than merely an absence of restraints placed upon the teacher by the institution that employs him. It demands as well an absence of restraints placed upon him by his political affiliations, by dogmas that may stand in the way of free search for truth, or by rigid adherence to a party line that sacrifices dignity, honor, and integrity to the accomplishment of political ends.

Those are words in which I take great pride, merely as a fellow citizen of President Allen. They are words in which any professional man can take particular pride, because they embody a reasoned, intellectual, and courageous approach to a difficult problem.

THE PROFESSIONAL ESTATE

I would not have you think that communism offers the professional engineer his only opportunity to understand and to act, aside from the specific confines of his job, because there are many others in which by the very nature of his key position in our economic scheme he has a vested interest. The whole profit system is today being closely examined—in fact, cross-examined is a better term—by men who at times seem, either through ignorance or malice, fanatically eager to destroy it. This has all the earmarks of an attempt to commit suicide with a boomerang. The antitrust laws today are being employed vigorously, abetted by conflicts and sweeping reversals in judicial interpretation, to raise questions of the most far-reaching economic importance to American industry. The whole question of the reorganization of the federal administrative machinery, with probable repercussions in the areas of tax structure, fiscal policy, and government control over business, is one that cries for consideration and expression by intelligent private groups who acknowledge an unpaid debt in public service. The list could be long, but it was not at all my intention to compile a list. I would not presume to be so explicit.

It was my thought to point out to you, as simply as possible, that curious parallel between the engineer's position today, and that of the early American scholar, and to impress you if possible with the worth and urgency of this examination of yourselves as responsible leaders in the modern community. Today *you* stand well at the head of those aggressive and important forces in American life which, by their very achievements, have added to their responsibilities. Because of the framework within which these remarks have been cast, I have been referring constantly to the "scholar" and the "professional man." These are, of course, only synonyms in our everyday speech for a much more elegant but exact term—thinking man. Professionalism is not so much a matter of license, or definition, or certification, as it is a matter of the way a man applies himself to the business of working and living. It is a matter of meeting ethical standards and balancing learning with human experience. It is a matter of open-mindedness and voluntary acceptance of responsibility, not only for your own performance but in some degree for that of others. The entrance requirements for membership in the professional estate are nowhere near as rigid and difficult to meet as are the requirements for maintaining that membership, and that is as it should be. One of your abiding characteristics must be that "confidence in the unsearched might of man" which Emerson recommended to his audience at Cambridge. And if you have any doubt remaining as to the timelessness of the professional estate, its privileges and its duties, it should be resolved by these words, significant to the Phi Beta Kappa Society in 1837, equally applicable to the AIEE in the winter of 1949:

> If there is any period one would desire to be born in—is it not the age of Revolution; when the old and the new stand side by side, and admit of being compared; when the energies of all men are searched by fear and by hope; when the historic glories of the old can be compensated by the rich possibilities of the new era? This time, like all times, is a very good one, if we but know what to do with it.

Wilson Salutes Edison Medalist

Charles E. Wilson (left), president of General Electric, congratulates Morris E. Leeds, winner of the 1948 Edison Medal, presented to Doctor Leeds at the AIEE winter session. (Page 192).

Our Institute

EVERETT S. LEE
PRESIDENT AIEE

IT IS GOOD to be able to attend the 1949 AIEE winter general meeting. It is always good to be in New York. With it comes a thrill, a thrill of greatness, a thrill of success, a thrill of accomplishment, a thrill of achievement, a thrill of work well done. In New York is our largest Section, nearly 5,000 strong, in itself a mighty power of electrical engineering achievement for great good.

This thrill of achievement does not arise from these boundaries alone, however. It comes from the great expanse of our Institute. Cast your thoughts with me to the Great Pacific Northwest—miles from New York—where our Sections in Vancouver, in Seattle, in Portland, in Spokane, and in Butte, together with the Student Branches in the great colleges of electrical engineering in this territory, stand as monuments of achievement of the electrical engineers.

Or turn your thoughts with me to our Subsection in Miami—miles to the south—where our Sections in Florida, Georgia, the Carolinas, and Virginia, together with the Student Branches in the colleges of electrical engineering in these states, reveal the electrical engineer as he who inspired the opportunities for electric power in this vast territory and keeps it going for man to have and to use.

Then move with me towards the west through Alabama, Tennessee, and Mississippi, where the eyes of the Nation have been on electric power, and again our Sections and our Student Branches are there, towers of strength in this vast field.

And move, if you will, northward with me to the great Midwest of our country—Illinois, Wisconsin, Michigan, Indiana, and eastward to Ohio, Maryland, Pennsylvania, and New York, where here, as everywhere else, our Sections and our Student Branches are serving, day-in and day-out, to provide more and more people with the benefits of electricity which have brought them further benefits which only a counting of our blessings can begin to reveal.

Since August it has been the privilege of your President to have visited our Sections, our Student Branches, our general meetings, our District meetings, and our conferences throughout these parts of our great country, and before the year is over, our visits will have been extended to San Francisco, Los Angeles, and San Diego, in the Southwest, again many miles from New York, and returning to include that great group of states from the Pacific to the Mississippi, and in the east of Canada, and in our own east.

It is impossible to contemplate such great power of contribution and wealth of achievement; still there it is for us to see and to have and to use, and in characterization I repeat again that statement I have borrowed from one of our associates, that it has been more revolutionary for the well-being of the people of the world than any other material thing in recorded history, that we have advanced electricity into every available avenue for the service of man.

This is the membership of our Institute at work. Every member contributes. Combined with their contributions we recognize those of our brother engineers, and of the great leaders of the industries of our land, and of the great contributions of the people in our shops and factories throughout our land who actually make the products for the people to have and to use, and of those in our government, and all others associated in the manifold operations of making things for people to have; all working together have made our country great.

It all starts with the scientist who brings new knowledge into being and with the engineer who fashions that new knowledge into metal for the use of mankind. The world needs engineers for engineering; the world needs electrical engineers for electrical engineering. This is our mission in life; and what there exists today attests to how well we have progressed our responsibility.

Everywhere I have found throughout our Institute that our electrical engineers are happy in their work. I have been characterized that I do not have a true concept of the hard cold facts of life with which an engineer continuously must contend. My answer to this is that just as engineers have shown the most outstanding ingenuity and ability in working together with their associates in harnessing the forces of nature for man to use, so they can apply this same ingenuity and ability in working together with their associates in bringing happiness to themselves if they are not happy.

I think I know what are the hard cold facts of life as well as any one, and I know of engineers everywhere who know them also, and who by their abilities have overcome them or still are striving to overcome them, for the cold hard facts of life are always with us; each morning finds some new ones, each evening some overcome. And so on, the next day. Herein is the formula of happiness—that there has been advance for good. When a man is not happy in his work, let him open the "advance for good" throttle in his engine and proceed.

There is always a better way. There is more for us to do ahead in our Institute. We have the necessary strength to do whatever we will to do. We are proud of "Our Institute."

Full text of the opening address by AIEE President Lee at the general meeting on Wednesday, February 2, of the AIEE winter general meeting, New York, N. Y.

Morris E. Leeds—Edison Medalist for 1948

The Edison Medal

A. E. KNOWLTON
FELLOW AIEE

IT HAS BECOME traditional for the chairman of the Edison Medal committee to preface the presentation addresses by a brief history of the medal and the way in which the recipient is chosen.

The Edison Medal was founded in 1904 by an organization of associates and friends of Thomas A. Edison who desired to commemorate the achievements of a quarter century of the art of electric lighting in which Edison had taken such a prominent part.

It was decided by the group that the most appropriate means of accomplishing this object was by the establishment of a gold medal which could serve as an honorable incentive to scientists, engineers, and artisans to maintain by their works the high standard of accomplishment which had been set by Edison himself. The AIEE was invited to undertake the responsibility of selecting the worthy recipients and making the awards. The Institute accepted the proposal and set up the Edison Medal committee composed of 24 members.

Three of these members are ex-officio—the president, the treasurer, and the secretary of the Institute, each year. Three are appointed each year by the president of the Institute to serve for overlapping terms of five years each. Three are elected each year by the board of directors from its own membership to serve for a term of two years each.

The bylaws of the committee provide for making one award each year and the "Deed of Gift" specifies that the award shall be made to some one resident of the United States or Canada for meritorious achievement in electrical science, electrical engineering, or the electrical arts.

The medal itself was designed by James Earle Fraser and carries on the obverse the portrait of Thomas A. Edison and, on the reverse, an allegorical conception of the genius of electricity crowned by fame.

The first award was made in 1909 to Doctor Elihu Thomson. It has been awarded to 36 others in the ensuing 39 years. The 1948 medalist, Doctor Morris Evans Leeds is thus the 38th to receive the award.

Presentation of the 1948 Edison Medal to Morris E. Leeds "for his contributions to industry through development and production of electrical precision measuring devices and controls" was made on Wednesday, February 2, during the 1949 AIEE winter general meeting in New York, N. Y. The Edison Medal, one of the nation's highest engineering honors, is awarded annually for meritorious achievement in electrical science.

Achievements of the Medalist

I. MELVILLE STEIN
FELLOW AIEE

THOSE WHO, like myself, have spent all, or nearly all, of their professional lives in the fields of measurement and control, will share my feeling of pleasure in the realization that the Edison Medal has been awarded this year for meritorious achievement in those fields. This is the first time in the 40 years since the Edison Medal was established, that instrumentation and control have been so recognized. A number of our Edison Medalists have made real contributions to these arts, but in no former case has the citation included a reference to them.

EARLY CAREER

Our medalist, after having been graduated from Haverford College in Pennsylvania, spent several years in teaching science. It happened to be the science of biology. He then made a careful appraisal of himself and, for reasons I never have been able to understand, decided that he was not cut out to be a teacher. Thereupon, he shifted his interests to the field of scientific instruments. I shall be able to mention only a few of his outstanding accomplishments, but these I believe to be typical, and I think you will agree that they establish our medalist as a great teacher, albeit not one of the classroom type.

As the first attribute of a good teacher, he always has been a thorough student; reading, consulting, and traveling at home and abroad to obtain full, and often first-hand, knowledge of what had been done in the field in which he happened to be interested at the moment. Shortly after having decided to make scientific instruments his life work, he enrolled at the University of Berlin to enlarge his knowledge of mathematics and physics. As most of you know, our medalist is a Quaker, and he has been a thorough student of Quaker business ethics as put into practice, particularly in England, by outstanding Quaker industrialists such as Rowntree and Cadbury. Because of its outstanding position in the scientific instrument industry, he studied

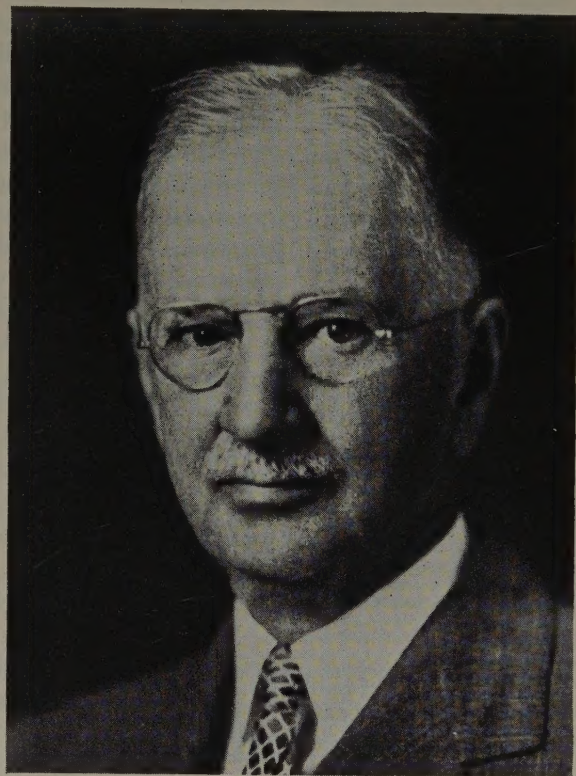
Full texts of the presentation and acceptance addresses made at the Edison Medal ceremonies on February 2, 1949, during the AIEE winter general meeting, New York, N. Y.

A. E. Knowlton, chairman, Edison Medal committee, is senior associate editor, *Electrical World*, McGraw-Hill Publishing Company, Inc., New York, N. Y.

I. Melville Stein is vice-president and director of research, Leeds and Northrup Company, Philadelphia, Pa.

particularly the philosophy of Doctor Ernst Abbe as applied to human relations in the great Zeisswerke at Jena. The demonstration that such principles and philosophies could be applied successfully in a different type of business and in a different country was, in itself, quite an achievement, and the particular arrangements and procedures adopted constituted real pioneering.

Perhaps the first thing that our medalist taught was that the manufacture of scientific instruments could be established successfully in the United States, 50 years ago, in competition with the then well established and highly respected organizations abroad.



Morrois E. Leeds

INTEREST IN RESEARCH

It was at about the turn of the century that he started manufacturing scientific instruments in this country. At just about that same time, industrial research departments were started by a few of our very large companies. About a decade later when such research departments hardly had had an opportunity to prove their real value, even in very large companies, our medalist established a separate research department in his very small company. He was very careful to distinguish clearly between research on the one hand, and routine engineering, testing, and control laboratory work on the other. Also, he set up a rather elaborate system of research accounting to collect figures from which to judge the merits of research in a small company. He had the courage to invest in research, during those early years, funds representing about 12 per cent of gross sales receipts. In 1919 he presented a paper in which he made a plea for "Industrial Research in Small Establishments," and presented rather complete data based on his research accounting system to show that it could be done successfully.[1] Coming at this rather early date, I believe his paper to be of considerable importance.

Then, he demonstrated that the more elaborate, but fundamentally sound, measuring methods, which had been well established for use in laboratories, were the only ones that could be depended upon for use in certain more difficult industrial process measurements. The criticisms of his early attempts in that direction approached very closely to ridicule, but Leeds had studied the situation thoroughly and had concluded that inasmuch as nature had made the forces to be measured every minute, it was up to the instrument designer to use methods and apparatus that could deal reliably with these very small forces. He reasoned that it was far better to use a multiplicity of parts in an instrument, each so lightly burdened that it had almost no chance of failure, than to use a simpler arrangement involving only a few parts, each of which had almost no chance of success. His teachings in that direction now are followed almost universally.

It very quickly became apparent that these machine-like industrial measuring instruments, which he developed, could be equipped with certain auxiliary devices to provide automatic control of industrial processes. To suggestions from within and without his own organization that these instruments be equipped with simple "on-and-off" electric contacts to provide automatic control, Leeds was very cool. He already had given considerable thought to automatic control because his industrial recording instruments involved in themselves some rather refined automatic control problems. He was satisfied that simple "on-and-off" control could not be expected to give good results in more than a few rather elementary applications. For the more difficult industrial control applications, he visualized the mental processes and the alert manipulations of an intelligent operator watching an array of measuring instruments and trying to make the adjustments necessary to maintain the desired conditions. He was convinced that unless an automatic control device took into account all of the factors, the weightings and the timings that a good operator did, it would not be successful; but he also was convinced that an automatic control device that did take into account all of these things could do a better job than the best operator could do. His visualization of sound automatic control was reduced to mathematical formulas and to experimental apparatus design at the time he applied for his pioneer automatic control patent in 1917.[2] These principles form the basis of all refined automatic control today. In the more than 30 years since Leeds applied for his patent, further improvements have been made in automatic controls, but it is interesting to note that these improvements have come from adding factors and functions rather than by omitting any that Leeds considered essential.

In a similar manner, when he took steps to establish his enterprise on an enduring basis, as free as possible from the pitfalls of absentee ownership, he found weakness in ordinary corporate structure and weakness in a partnership arrangement; but by superimposing a voting trust arrangement on top of a corporate structure he sought to gain the advantages of both and minimize the weaknesses of each. This

involved a complex deed of trust for determining voting rights, share values, and similar matters, but Leeds did not let the complexities involved stand in the way of introducing the elements necessary to give the controls desired.

Likewise, in setting up an employee representation plan more than a quarter of a century ago, which was to deal, among other things, with wages, hours, working conditions, unemployment insurance, profit sharing, and many similar features, he did not shy away from the multiplicity of committees and procedures which were essential to accomplishing the intended purpose. The success of the plan may be judged in part by the fact that it won the *Forbes Magazine* prize in competition with a number of outstanding employee representation plans in effect in a number of progressive companies. And all of this happened long before the "New Deal" burst upon us.

Lest you get the impression that our medalist has an aversion to simplicity, and an obsession for complexity, I hasten to assure that such is not the case. Actually, the Leeds characteristic procedure of including all of the elements and steps essential to reliable operation puts an added premium on the elimination of nonessentials, because it is obvious that the elimination of a nonessential element, or step, permits the addition of a new and useful one without adding to the complexity as a whole.

HONORS

Leeds' interest in education has led to his appointment to the boards of many educational institutions. For 17 years he served as president of the board of managers of Haverford College, and for 10 years he was president of the Board of Public Education in Philadelphia. He has been honored by the Brooklyn Polytechnic Institute with the degree of doctor of engineering, and by Haverford College with the degree of doctor of laws.

The Edward Longstreth Medal of Merit of the Franklin Institute was awarded him in 1920 for his invention of the Leeds and Northrup mechanical recorder. In 1946 the American Society of Mechanical Engineers awarded him the ASME Medal "for outstanding achievements in the invention and development of electrical- and temperature-measuring instruments and in the field of industrial relations."

For his activities in the field of management he received the Henry Laurence Gantt Medal from the Institute of Management in 1936, "for distinguished achievement in industrial management as a service to the community." In 1946 he received the first Rotary Award of the Rotary Club of Philadelphia "in recognition of outstanding accomplishments in his consistent application of the principles of good will and brotherhood, in business, education, industrial management and world citizenship."

Finally, I should like to mention just two personal characteristics of our medalist. The first is his characteristic of analyzing very carefully mistakes and failures, the relatively few of his own, and those of others he has had the opportunity to observe closely. These mistakes he has memorized in intimate detail, and has turned them to advantage in later plans and activities. Those who shared my good fortune of having worked directly with Edison will recall how reluctant he was to abandon an incompleted experiment even after it was clear that the result would spell failure at the moment. He preferred to complete the experiment and carefully record and analyze the results, so that years later he could turn the failure to advantage in some other effort. The other personal characteristic of Leeds' that I wish to mention is willingness, even anxiety, to learn from people in all walks of life, young people, rank and file workers, and those whose manner of thinking is quite different from his own. He has a great and sincere respect for ideas and opinions learned through such sources, but regardless of the sources of his information and advice, I never have known him to compromise with sound, basic principles, whether in the field of physical science, ethics, finance, or human relations.

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The Growth of an Industry

MORRIS E. LEEDS
FELLOW AIEE

I CANNOT OVEREMPHASIZE my profound appreciation of the great honor which the AIEE has conferred on me by awarding me the Edison Medal. Reviewing the names of the 37 previous medalists and finding on the list such men as Thomson, Westinghouse, Brush, Bell, Pupin, and Millikan, and others like them, it is with wonder and gratitude that I take a place as a minor luminary in this galaxy of first magnitude stars.

The citation accompanying the medal refers to electric and precision measuring devices and controls, and I must assume that this award is to a considerable extent a recognition of the part which measuring instruments of all kinds have played in the country's industrial growth. So it may be appropriate for me to review some of the highspots of the instrument industry's development as I have seen it during the last half century.

THE INDUSTRY'S BEGINNING

In Philadelphia the industry can trace its beginning to Benjamin Franklin and his time, but it was until comparatively recently very small. When I was serving my apprenticeship in the early 1890's, scientific instrument manufacture still was struggling for a foothold in the United States, and the shadow of Europe was over everything that we attempted. My work included the unpacking and checking of a great many European instruments. These so com-

Morris E. Leeds is an inventor and is chairman of the board of directors, Leeds and Northrup Company, Philadelphia, Pa.

manded my respect that, having decided on the instrument industry for my career, I arranged to spend a year in Germany, and while there I visited most of the prominent instrument makers from Glasgow and London to Geneva, Prague, and Vienna. Kelvin and James White, the Cambridge Scientific Instrument Company, Nalder Brothers, Elliott Brothers, Carpentier, Otto Wolf, Siemens and Halske, Hartmann and Braun—just to mention a few—were great names in those days, and my visits to their establishments gave me great respect for their ability as instrument makers. Those were the days when many college professors believed that they had to complete their education by work in Germany. They came back to America with the deep conviction, which was true barring a few noteworthy exceptions, that foreign instruments were better than those being made in this country, and the further conviction in many cases that they were better than any that could be made here.

Aside from the prejudice in favor of European apparatus, we were dependent on Europe for essential materials, including hard rubber, optical parts, galvanometer mirrors, and manganin in all its forms. We had to pay a duty on these materials when we imported them, at the same time that under the law then in effect educational institutions could import scientific apparatus free of duty; so the same materials coming in to them, but made up in instruments, were free of duty.

These handicaps against which the struggling beginner in instrument manufacture had to work 50 or 60 years ago gradually vanished during the early decades of this century. The privilege of duty-free importation was abolished. Prejudices in favor of foreign manufacturers were replaced gradually by reverse prejudices, particularly against Germany after the first World War. For a good many years now it has not been necessary to import any manufactured foreign materials; price, quality, and reliability of supply make it more satisfactory to purchase in this country. The Bureau of Standards was established as an independent institution and made it entirely unnecessary to send instruments to the Reichsanstalt, or any other foreign standardizing laboratory, to be certified.

In the earlier days the laboratories of educational institutions and of certain government departments were the industry's chief customers, except for such instruments as switchboard ammeters and voltmeters, pressure gauges, and so forth, which already were beginning to be used extensively in power plants. But recorders scarcely had appeared, and controllers were not yet seriously considered. The telegraph and telephone industries were also among the earliest to use instruments extensively, which they did to measure insulation resistance, locate faults in long lines, and, gradually, for many other purposes. Like extensive use of instruments now has spread to many other industries.

IMPORTANCE OF ELECTRICAL MEASUREMENTS

The versatility of electrical measuring methods is largely responsible for this. Among the diverse physical and chemical measurements made electrically are temperature, strain, acidity, solution concentration, composition of gases, and automatic quantitative analysis of several elements in the same solution. Many of these are basically electrical measurements and not merely electric transmission of measurements made by other methods. For instance, electrical measurement of acidity, or pH, is a measure of the concentration of hydrogen ions, and this concentration is measured directly by electromotive force. In addition to the ability to measure quantities not generally considered electrical, electrical measurements have the advantages of utilizing tremendous amplification, of ready transmission over considerable distances and of automatic actuation to provide recording and control.

Electrical scientists and engineers may feel properly proud of the contributions made by electrical measurements to all technology and industry. Many of these contributions have been made by members of the Institute, which long has maintained an active technical committee on instruments and measurements. Admittedly, we owe much to fine optical and mechanical instruments such as the microscope, the spectrograph, the gyroscopic compass, and the venerable mechanical clock. On the other hand, we find the electron microscope opening new fields beyond the range of the optical microscope, and crystal oscillators providing time measurement and control beyond the abilities of the most precise mechanical clocks. In the field of spectrography, combinations of electric elements with the usual optical elements are opening new frontiers.

As an indication of the manner in which electrical measurement and control have become essential parts of most continuous industrial processes, I may cite an example from a familiar industry, the electric central station industry. Here electrical instrumentation plays a very important role in the control of load and frequency and does much to make practicable the tie-in between large electric distribution systems, and incidentally, to assure the frequency control that makes electric clocks so useful and popular.

As another indication of the important position now held by measurement and control, the United States alone now

Edison Medalists

Elihu Thomson	1909	Frank Conrad	1930
Frank J. Sprague	1910	E. W. Rice, Jr.	1931
George Westinghouse	1911	Bancroft Gherardi	1932
William Stanley	1912	Arthur E. Kennelly	1933
Charles F. Brush	1913	Willis R. Whitney	1934
Alexander Graham Bell	1914	Lewis B. Stillwell	1935
Nikola Tesla	1916	Alex Dow	1936
John J. Carty	1917	Gano Dunn	1937
Benjamin G. Lamme	1918	Dugald C. Jackson	1938
W. L. R. Emmet	1919	Philip Torchio	1939
Michael I. Pupin	1920	George Ashley Campbell	1940
Cummings C. Chesney	1921	John B. Whitehead	1941
Robert A. Millikan	1922	Edwin Howard Armstrong	1942
John W. Lieb	1923	Vannevar Bush	1943
John W. Howell	1924	E. F. W. Alexanderson	1944
Harris J. Ryan	1925	Philip Sporn	1945
William D. Coolidge	1927	Lee de Forest	1946
Frank B. Jewett	1928	Joseph Slepian	1947
Charles F. Scott	1929	Morris E. Leeds	1948

has three journals devoted to the many phases of those subjects.

In the 40 years since the Edison Medal first was awarded, rule-of-thumb in industry has been replaced very largely by accurate measurement, and in the arts both of peace and of war instruments for measuring, recording, and controlling are to be found guiding and regulating very many processes to insure efficiency, quality, and quantity of output.

THE SOCIAL ASPECTS

A thoughtful person cannot contemplate the successful prodigality of all these industries which a review of instrument application brings to his attention without at the same time noting with dismay the lamentable failure of our society to use the great resources which industry provides to help insure a better social order and an increasing measure of peace and security, nationally and internationally. Fifty years ago we were in what Henry Seidel Canby has called the age of confidence. We confidently believed in the soundness of our institutions, and we fully expected that the progressive conquest of natural resources would enable us to fashion a healthier and happier social order. So it is indeed cause for dismay that our growing resources seem to diminish rather than increase our progress in these desirable directions.

Such reflections as these evidently have troubled the consciences of engineers, because there is much discussion of the engineer's responsibility for the social effects of these industrial successes to which his particular knowledge and skill have contributed so conspicuously. Meetings have been devoted to the subject and able papers have been presented. Out of it all there seems to be an emerging consensus of opinion on engineering responsibility for the social order which may be summarized as follows:

> It is society as a whole, rather than our engineers and scientists, which is responsible for the use that is made of our technical developments.
>
> The engineering disciplines do not equip one with particular knowledge or skill that is likely to be useful in the social field.
>
> But engineers do have an approach which is typically, though not uniquely, theirs, and which well might be employed much more thoroughly than it is in attacking social problems. These are the essentials of this approach: the definite formulation of the problem, the assembly of all pertinent information that is available and its analysis, and on this basis the formation of plans for dealing with the situation—all to be done within a limited, specified time.

Having acquired skill in the practice of this approach, the engineer does, it seems to me, have a moral responsibility as a citizen to make it useful in dealing with social problems when he has the opportunity. Although this is not the time to explore the avenues through which this approach may be applied, it may be said safely that economic planning is one of them, and I bring that in because I want to refer to a widespread experience in the precision instrument industry that possibly may carry over into that of economic planning. It often has happened in the instrument field that the use of measuring and recording devices to obtain pertinent information has shown the need for controlling devices. One would not be warranted in making the deduction that in the social field a more complete assembly of pertinent information would indicate a need for more controls, but he certainly would not be warranted in assuming that it would not. It is interesting to speculate whether the engineering approach, applied rigorously and without prejudice, would lead us to more or less government control of industry. Our analogy certainly would indicate that such controls might be difficult and complicated, and call for the exercise of much care in their application, but that if soundly applied where needed, their advantages would be conspicuous.

May I conclude this brief discussion of the engineer's social responsibility by quoting from a paper which I wrote some years ago?

> It is not the vast knowledge of the engineer nor the skills and techniques of the profession, useful as these may be, that put him in position to make a uniquely valuable contribution to the art of dealing with complex economic situations; but I believe he can make such a contribution by passing over into the field of economic practice his habitual way of looking at and dealing with problems, which leads him to see clearly what he wants to accomplish, to take into account systematically all the factors and circumstances which will influence results, and then plan so that the objective may be achieved as nearly as possible by the time wanted and under existing conditions.

$1,000,000 Transformers

A dozen 15,000-volt General Electric transformers were until recently the most heavily guarded pieces of power equipment in this country. Their solid silver, million dollar windings, utilized at the height of the war-time copper shortage, have been removed, and the metal returned to the United States government. Conventional copper windings are shown being installed at General Electric's San Francisco, Calif., service shop. The original silver was obtained from the government silver cache at West Point, N. Y., and the units, were so designed that the silver windings could be replaced when copper was available

Contact Bridge Erosion and Its Prevention

W. G. PFANN

As ELECTRIC CONTACTS separate, a molten metallic bridge forms between them and then breaks. A transfer of contact material, called bridge erosion, accompanies the rupture of the bridge. If the inductance in a d-c circuit is reduced sufficiently and if the battery voltage is below the minimum for arcing, the phenomena of the molten bridge can be isolated for study. Careful examination of contacts operated under conditions in which bridge erosion predominates shows that, despite a gross transfer of material from anode to cathode, the explosion of a molten bridge leaves a small crater in each contact. The diameters of such craters are believed to be those of the molten bridge just before rupture and they vary with current and with resistivity of the contact material and in the expected manner.

Although for some materials the bridge has equal diameters in the two contacts, in other cases it is asymmetric, that is, the diameters in the two contacts may differ considerably. Results of bridge erosion tests suggest that a transfer of material in the direction of the smaller end of the bridge is associated with such asymmetry. By pairing two materials which differ in "natural" bridge diameter an "artificial" asymmetry is created. The transfer tendency of such a combination is called here "asymmetry transfer" and is shown to be self-limiting, because the act of transfer causes the gaining electrode to become similar to the losing one, thus removing the driving force causing the action.

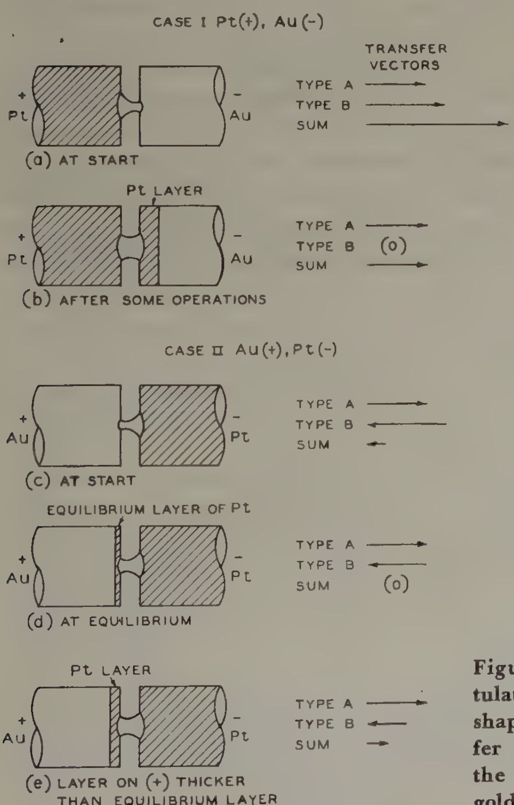

Figure 1. Postulated bridge shapes and transfer vectors for the platinum-gold combination

a

b

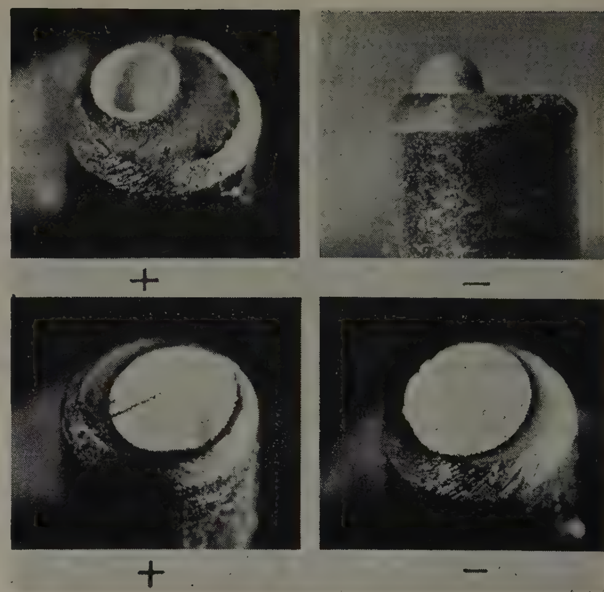

Figure 2. Erosion of the combination platinum−20 iridium against gold at 6.3 volts, 5.3 amperes: (a) Pt−20Ir(+), Au(−), 1,000,000 operations; (b) Au(+), Pt−20Ir(−), 2,066,000 operations; Magnification−40×

Development of the concept of "self-limiting transfer" shows that a condition of zero net transfer will result if contacts are operated when asymmetry transfer is greater than the resultant of other transfer forces acting on the contacts, and is opposite in direction to that resultant. This concept is illustrated by the vectors and sketches of Figure 1, wherein asymmetry transfer is designated *B*, and the resultant of other transfer actions is designated *A* (assumed constant and negative). Experimental verification is shown by the examples of Figure 2.

Contact materials may be classed as *I* or *II* depending on whether their natural bridge diameters are small or large, respectively. Any member of class *I* may be used with any member of class *II* to establish a condition of self-limiting transfer. Instead of two homogeneous contacts, one of each class, it is equally effective to use two similar duplex contacts, each having a thin class *II* layer on a class *I* base. Such configuration is independent of polarity or change in polarity and may be used to conserve precious metals.

Since a thin, class *II* layer whose thickness is invariant with time is formed on the class *I* base at equilibrium, the principles described here suggest a means of coating one metal on another in a well-bonded layer or uniform but controllable thickness.

Digest of paper **48-274**, "Bridge Erosion in Electric Contacts and Its Prevention," recommended by the AIEE basic sciences committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting Milwaukee, Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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Performance Characteristics of Speed Governors

L. B. WALES

THE PERFORMANCE CHARACTERISTICS of speed governors on automatic extraction turbines as related to the performance characteristics of governors on straight condensing and noncondensing extraction turbines are affected by the characteristics of the turbines themselves. "Steady state regulation" and "overspeed" may require either special treatment or additional mechanism in the governing system in order to maintain acceptable values. The addition of the "extraction pressure regulating system" requires correlation of its action with that of the speed governing system, if the additional duty that otherwise would be imposed on the speed governor is to be avoided.

The performance characteristic by which speed governors are best known is "regulation." An acceptable value is in most cases three to four per cent. Nonautomatic or reducing valve extraction from such a turbine, sufficient only to heat feedwater to supply steam to the turbine, usually can be accomplished within acceptable tolerances of speed change.

The speed governor performance on an automatic extraction turbine, equipped with a similar speed governing system and an independent extraction pressure regulating system, may be acceptable with respect to the defined "regulation" (change in speed when the power output changes); but speed changes equal to several times the "regulation" may occur without change of power output when steam is extracted. The diversion of large quantities of steam to the extraction line requires large movements of the "governor-controlled valves" to maintain the power output and results in correspondingly large speed changes.

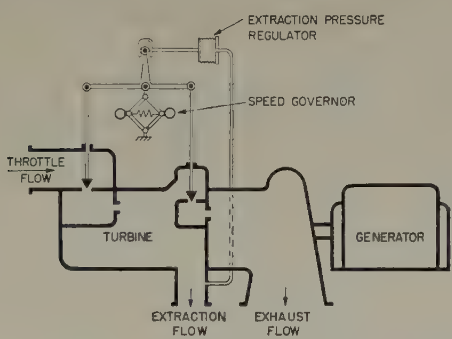

Figure 1. Compensated control system

Significant speed changes due to extraction of steam may be eliminated by the use of a speed governing system with very small steady state regulation (approaching zero); but since only one unit of such regulation can be operated on a system at one time, this solution is rather limited and inflexible. When an automatic extraction turbogenerator, equipped with a "speed governor system" and an independent "extraction pressure regulator system," is operated in parallel with an infinite electrical system or in parallel with a turbogenerator of very small speed regulation, extraction changes result in a corresponding change of the power output of the automatic extraction turbine.

The use of various forms of "compensated control systems," in which the "speed governor system" and "extraction pressure regulator system" are interconnected to correlate the action of both systems, either eliminates or reduces to within practical limits the speed change otherwise associated with extraction flow changes.

The action of a "compensated control system" is illustrated diagrammatically in Figure 1. Both hydraulic and mechanical interconnections are employed practically, and produce results that can be visualized readily with this diagram.

The performance characteristics of speed governors on automatic extraction turbines, with respect to "overspeed" (the maximum increase in speed following a sudden reduction of turbine power output) under conditions of maximum extraction, may require special consideration and provisions. With a given "regulation," "overspeed" is greater on automatic extraction turbines than on straight condensing and nonautomatic extraction turbines, unless provisions are made to maintain the "regulation" when operating at maximum extraction.

Decreasing the "regulation" constitutes one method of controlling "overspeed" on automatic extraction turbines to within a value that will not trip the emergency stop valve. This method is simple and does not require additional mechanism. Small regulations, however, do not promote stability. Stability either on an individual unit or on units operating in parallel must be achieved in spite of small regulations that may exist. Another method of controlling "overspeed" on automatic extraction turbines at acceptable values is to arrange the "interconnections" between the speed governing and extraction pressure regulating systems so that the same value of speed "regulation" exists whether operating with zero extraction or with maximum extraction.

This and similar methods of modifying compensated control systems to control overspeed possess an important advantage for the operation of an automatic extraction turbine electrically in parallel with other units, because the extraction pressure regulator is prevented from supplying more extraction steam than that which will just generate the power being carried by the generator. The power output interchange between the extraction turbine and the other turbines which otherwise would result is eliminated.

Digest of paper 48-282, "Performance Characteristics of Speed Governors on Automatic Extraction Turbines Driving Electric Generators," recommended by the AIEE power generation committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Not scheduled for publication in AIEE *TRANSACTIONS*.

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Effects of Electricity on the Human Body

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With the advent of man-made electricity, still another contributing factor to the mortality rate comes up for consideration; in the utility field alone employee deaths ascribable to electricity currently average 70 to 80 per year. As a matter of general information for the engineer working with electric current, this article discusses the basic principles and data concerning electric shock and indicates some of the physiological conditions which result.

ONE OF THE CAUSES of death on this planet that has existed since the time of creation is lightning. The true nature of this cause, however, was not recognized until the researches of Benjamin Franklin, 1749 to 1752, established the fact that a lightning stroke was an electric discharge on a grand scale and involved the flow of an electric current. In 1753 one of the experimenters in this field, Richmann of St. Petersburg,[1] was killed by a discharge. The first man-made electric shock of which we have any record occurred in Holland in 1746, when two Dutch physicists unintentionally discharged a Leyden jar through their bodies. The first reported death due to man-made electricity occurred in France in 1879, and the second in Scotland a year later. Today in the United States and Canada the number of fatalities annually ascribed to electricity is seven per million of population, and approximately half of the accidents reported are fatal. In the utility field the number of deaths of employees ranges from 70 to 80 per year.

FACTORS

In determining the effects of the passage of an electric current through the body there are certain factors that should be taken into consideration. They are

1. Type of circuit with which contact is made.
2. The voltage of the circuit.
3. The resistance offered by the human body.
4. The value of the current that flows through the tissues.
5. The pathway of the current through the body.
6. The duration of the contact.

These six factors are related to each other and no attempt has been made to arrange them in the order of their importance. In some instances it is impossible to discuss a single factor separately.

The Circuit. The type of circuit and its voltage, with which contact is made, have a profound effect upon the resulting injury. D-c circuits do not produce the strong contraction of the muscles that is found with alternating current, and in general the sensation produced by direct current is greatest when the circuit either is made or broken. Low-voltage d-c circuits are not as dangerous as the corresponding a-c circuits. In fact, there is only one case on record that the author has knowledge of where a man was killed on a 120-volt d-c circuit in which there was no possibility of a high induced voltage due to the opening of a field circuit or similar cause. On the other hand, contact with high-voltage d-c circuits is more apt to be fatal than contact with alternating circuits of the same voltage. In cases of lightning shock the musculature contraction is usually absent.

With alternating current there is little if any significant difference[2,3] in the reactions of the body to shocks from 25- and 60-cycle circuits. Dalziel[4] has found that the response of the human body is practically uniform for frequencies ranging from 10 to 300 cycles per second. At 1,000 cycles a somewhat greater value current is required to produce a given reaction, while very high frequencies, such as are used in diathermy, have only a heating effect.

The effects produced by interrupted direct currents vary not only with the period of the interruption but also with the cycle followed. An exponentially rising unidirectional current is the most efficient for the stimulation of nerves.[5] As such wave forms are difficult to generate, square or rectangular waves usually are employed. Square waves are almost as effective as the exponential type, and they are generated and controlled more easily.

Voltage. People recognize that high voltages are dangerous. However, they should be equally careful of low voltages. There are a number of cases on record where contact with 60- and 65-volt circuits of commercial frequencies have resulted in fatal accidents. The lowest voltage fatality of which the author has any record occurred at 46 volts, 60 cycles. It is probable that circuits of 24 volts or less may be considered as safe under practically all conditions.

Resistance of the Body. The resistance of the body consists of two parts, that offered by the skin at the points of contact and the internal resistance. The skin consists of two principal layers. The outer skin or epidermis is from 0.05 to 0.2 millimeter thick. It is nonvascular and on the palms and bottoms of the feet horny and calloused. The inner skin, or derma, is from 0.5 to 1.7 millimeters thick and contains blood vessels and nerves. Dry epidermis has a high resistance which may reach 100,000 ohms per square centimeter. The resistance offered by the inner skin is low, as body fluids and blood are good conductors because of their salinity. In fact, the only poor conductors inside the body are the bones. The internal resistance of the body is therefore relatively small.

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The equivalent electric circuit of the body consists of three parts. Where the current enters, the epidermis acts as capacitor with a poor dielectric. The tissues of the body act as pure resistances and provide a homogenous path for the passage of an electric current. At the point where the current leaves, we again have a capacitor with a poor dielectric. This may be demonstrated by taking an oscillogram of the current when a continuous potential of 50 volts is applied to electrodes held in the hands. At five microseconds after closure of the circuit a current of 19 microamperes was recorded. At 500 microseconds the current had fallen to three microamperes. At 10,000 cycles the power factor of the body of a normal healthy person is about 0.1.

The resistance of the skin is not constant. It varies with the amount of moisture that it contains, the temperature, and the applied voltage. Under thoroughly wet conditions, the resistance of the epidermis may fall to as low as 1/100 of its dry value. If contact with a circuit continues for any length of time, the skin loses its protection because of the formation of blisters. At 50 volts blisters form in six or seven seconds. The relationship between a 60-cycle voltage and the resistance offered to the flow of current is illustrated in the following table.

Alternating Voltage	Average Resistance (Ohms)	Range Resistance (Ohms)
50	10,000	5,000–18,000
500	1,200	800– 1,800
1,000	1,100	800– 1,800

These readings were taken three seconds after the circuit was closed, and were made on cadavers. The circuit through the body was from hand to hand. When the epidermis was removed, the resistance was found to be practically independent of the voltage. In general, the skin of the female is of lower resistance than that of the male. This is true for skin taken from such areas as the abdomen and back where callousness is not present. An individual's skin resistance also increases considerably (about double) when asleep.[6]

Current. The value of the alternating current that flows through the body when contact is made with an electric circuit is of extreme importance as it determines the resulting injury. Current values that are of interest are

1. Threshhold of feeling.
2. Let-go current.
3. The freezing current.
4. The current which an individual can withstand without being rendered unconscious.
5. The current that will produce ventricular fibrillation.
6. The current which will produce a block in the nervous system.
7. The counter shock current.

The current that will just produce a tingling sensation which can be detected at the point of contact, is of the order of one or two milliamperes. Some individuals, particularly women, are extremely sensitive to small currents. Other individuals are not so sensitive. The sensitivity of an individual to detect a small current also varies with his physical state.

It is well known that contact with an electric circuit produces a contraction of the muscles. This contraction may be so severe as to prevent the victim from freeing himself from the circuit. The let-go current is that value of current which an individual can withstand without harmful effects for at least the time required for him to release his hold on the circuit. Professor Dalziel[4] has made an exhaustive study on a representative group of men and women and reports that for men the standard frequency let-go current is nine milliamperes and for women, six. This is the current value that 99.5 per cent of the individuals tested could release voluntarily. The value of the let-go current varies with the individual and Dalziel found that for men it ranged from 8 to 22 milliamperes.

The current that will hold an individual frozen to a circuit is naturally in excess of his let-go value. Because of the heating produced by the current where it passes through the epidermis and the short time required for the skin to blister and lose its protective resistance, this freezing current should be avoided at all costs. Unless there is someone present to break the circuit, the result may be fatal.

There is no information available as to the current that an individual can tolerate without losing consciousness. The lowest value of current that will produce unconsciousness is somewhere between the let-go current and that required to produce fibrillation.

A current of 100 milliamperes flowing from the hands to the feet is sufficient to throw the ventricles of the heart into fibrillation. This value of current is not large enough to hold the heart in diastole; instead it disturbs the rhythm and co-ordination of that organ. Each individual heart muscle functions without regard to the others, and the action of a heart in fibrillation looks like the ripples that flow across a puddle when a pebble is dropped into it. In this condition the circulation of the blood ceases, because the heart no longer acts as an effective pump.

The current that will produce a block or partial paralysis in the nervous system is of the order of several amperes. The nerve block prevents the signal from the brain reaching the lungs and natural breathing ceases. Artificial respiration should be applied promptly in such cases.

The counter shock current is that current which will bring the ventricles of a fibrillating heart to rest. A 60-cycle counter shock current of between one and two amperes applied directly to the heart will arrest fibrillation. When this current is broken sharply, the heart usually will resume its normal co-ordinated beating. There is no information available as to the most advantageous location of the electrodes nor as to the current value required when the electrodes are applied externally to the body.

Pathway Through the Body. The pathway that the current traverses in its passage through the body is of extreme importance. In general, if there are no vital organs, such as the brain, the heart, or the lungs, in the current path, the resulting injury is a minimum one (burns excepted). For example, in some experiments[7] on rats in which the animals were given a 2-second shock at 220 volts, 60 cycles, all those where the current path was from foreleg to foreleg

died; while those where the path was from hindleg to hindleg survived.

In most industrial accidents the current path is from the hands to the feet. This path involves the heart and the lungs and is, therefore, particularly dangerous. When contact is made at two points on the same arm or leg, no current passes through the trunk. In fact, when current enters the body via one leg and passes out through the other, no vital organs lie in its circuit.

Once the current enters the body trunk, it follows a more or less fusiform pattern. When through-type current transformers were inserted in the body, it was found that approximately ten per cent of the total current passed through the heart when the current pathway was from one hand to the feet.[8]

Duration of the Contact. The duration of the contact should be as short as possible, and the higher the voltage, the shorter should be the time of contact, if there is to be any hope of recovery. In fact, duration of the contact should be as brief as the janitor's Christmas. During prohibition days a janitor was waiting for a trolley car at the corner. A car came along and as he boarded it, a bottle dropped from his coat and broke, and a colorless liquid flowed out. The janitor looked down. His face was long and sad as he said, "Christmas done come and gone."

EFFECTS

The passage of an electric current through the body produces numerous effects that differ not only in intensity, but also in kind. They range all the way from a slight tingling sensation to death. The consequences depend upon the value, frequency, and pathway of the current and on the duration of the shock. The aftermath may be good or evil. An electric shock may produce healing in certain mental diseases or it may produce a state of depression of the vital processes of the body characterized by rapid but weak pulse, rapid but shallow breathing, pallor, restlessness, and a depressed mental state similar to surgical shock or a highly excited, almost maniacal state. Some of the effects produced by an electric current are discussed in the following.

Conscious Phenomena. If the victim of an electric shock retains consciousness during and following the contact, there is often a whistling or ringing in the ears and partial deafness for a time. In addition there may be visual disorders such as flashes and brilliant luminous spots. Pain and soreness of the muscles are a common reaction. If the shock is a severe one, the victim usually will be restless and irritable. These disorders generally disappear in a few hours.

Muscular contractions are produced when contact is made with an electric circuit. These contractions are particularly marked when the circuit is an alternating one of commercial frequencies. At high voltage the tetanus of the muscles is very sudden and severe. It may throw the victim clear of the circuit. In some instances bones have been broken. The severity of the contraction probably accounts for the soreness that is felt in the muscles. Clonic contractions of the extremities often are observed following a shock and tremors may continue for some minutes.

Convulsions may occur in cases of electric shock. They usually are characterized by irregular muscular spasms and tremors.

Electric shock therapy[9] has been used by psychiatrists in the treatment of psychosis. It has been found most affective in treatment of depressions. Here electrodes are placed on the sides of the skull and the current passes through the brain. A sufficient current is used to cause a convulsion. The source of power is generally of standard frequency, and means are provided for varying the voltage from 70 to 130 volts. The duration of the shock ranges from one-tenth to a half a second and the current from 200 to 1,600 milliamperes. The number of treatments given to an individual shows great variation, but a course of 12 shocks is perhaps an average. The treatments usually produce a marked impairment of memory, but memory usually is restored completely a few weeks after the therapy is stopped. Marked changes are found in the electroencephalogram which records spontaneous electric discharges from the brain. There is no universally accepted theory which explains the value of electric shock in therapy. Some speak of profound physiochemical changes in nerve cells while others believe that the shocks form an acceptable punishment which relieves the patient of guilt. Although this treatment is used so commonly, there are only a few cases of death following the shock and permanent symptoms due to damage to the brain are rare.

Narcosis, a state of stupor and insensibility, has been claimed as one of the results of shock. When the passage of an electric current through the brain of patients causes convulsions, it also produces unconsciousness lasting for several minutes. This unconscious period might be considered anesthesia inasmuch as the patient is insensitive to pain. Recently this unconscious period has been employed by some surgeons to perform short operations. And others[10] have attempted to produce periods of narcosis in the treatment of psychotic patients by utilizing lower values of electric current and thereby eliminating the convulsions.

Anesthesia resulting from the passing of interrupted direct currents through the head was claimed by Leduc of Leipzig in 1902. Other investigators including the author, have repeated Leduc's experiments without success. Hertz[11] in his thorough study of the subject, found that anesthesia was not attained either in animals or man. Instead the patient would be rendered unconscious and breathing would cease unless the strength of the shock was limited carefully. A so-called electric anesthesia[12] is used by the British in the slaughtering of hogs. One electrode is placed in the mouth, the other on top of the head, and a 50-cycle current is passed directly through the brain, rendering the animal unconscious. The bleeding of the animal is reported to be better following this treatment than in normal slaughtering practice because of the increased blood pressure that follows the shock.

Loss of consciousness occurs in many electrical accidents.

Sometimes the victim recovers spontaneously; in other cases, either after the application of artificial respiration, or never. Cases also have been reported where the victims lost consciousness when contact with the circuit was made at two points on the same leg or hand, and in which there was no burning of the tissues. Such cases are believed to be due to a severe shock to the system.

Electric burns are of two types, those produced by the heat of the arc, as may result when contact is made with a high-voltage circuit, and those that are caused by the passage of the electric current through the skin and the tissues. Burns resulting from an electric arc are, in general, similar to those produced by high-intensity heat sources. The true electric burn often is characterized by a pinkish mark on the surface of the skin. The burns, however, may penetrate deeply and require considerable time to heal. Jellinik[13] reports a case where the current value was large enough actually to char the flesh at the elbow where there exists only a relatively small amount of body tissue. Burns, blisters, and markings are not necessarily present on the skin after an electrical accident. When the skin is saturated thoroughly with water and the contact area is not restricted, a fatal shock may not leave the slightest detectable blemish. Burns produced by electricity usually heal without infection. They, however, heal slowly. In severe cases fingers or limbs may be lost and death may follow as a secondary effect.

Emission of seminal fluid is common in males and occurs at low as well as high voltages. It is believed that the severe muscular contraction is responsible for this effect.

Priapism has been observed in a number of instances and in some cases has continued for a week. This phenomenon is believed to be caused by an irritation produced in the spinal cord by the flow of current.

Incontinence is reported in some cases following a shock and in some instances blood is present in the urine.

Blood pressure rises suddenly when contact is made with a high-voltage circuit because of the severe muscular contraction. When the circuit is broken, the pressure usually remains high for a period due to the rapid heart rate; provided that organ is not injured by the shock.

Hemorrhages usually petechial in nature sometimes are found in the brain, the nervous system, and other organs. One or both eyes may be bloodshot following a shock, due to the rupturing of blood vessels in the conjunctiva. Gross hemorrhages have been found in the fourth ventricle of the brain upon autopsy.

The nervous system[14] may be so profoundly shocked or fatigued by a contact with an electric circuit that it cannot function normally again for a period of minutes or hours. The nerve cells are injured, especially in areas that have been traversed by the current. Injured cells are characterized by a dark shrunken nucleus, which is often eccentric in position, and the loss of granules. The damage, however, is patchy in distribution so that injured and normal healthy cells lie in close proximity. Autopsy of shock victims also has revealed cavities in the nervous system of 25 to 200 microns in diameter. These may be caused either by heat or electrolysis.

One of the most common effects on the nervous system is the production of a temporary paralysis or block. The location of this block will depend upon the path taken by the current. The lungs or other portions of the body may be paralyzed following the shock. There is a case on record where a woman stood with her back resting against the edge of an electric range when the power line was struck by lightning. She received a severe shock which was followed by a temporary paralysis and loss of sensation in both limbs that lasted for about four hours. The many successful resuscitations resulting from the prompt application of artificial respiration to shock victims may be ascribed to the temporary nature of this paralysis. If nature is given the opportunity, it often will repair the damage and again permit the signal from the brain to reach the organ in question.

The damage that electricity produces in the nervous system is not specific in that other diseases give rise to similar patterns.

Ventricular fibrillation results when a small current passes through the heart and disturbs its normal co-ordinated rhythm, as explained in the foregoing. The human heart does not recover spontaneously from ventricular fibrillation. While the heart is in this condition there is no circulation, and death will ensue.

Ventricular fibrillation may be arrested by the passage of a 60-cycle current of the order of one to two amperes through the heart.[15] This value of current is sufficient to bring the muscles of the heart to rest and hold that organ in diastole. Then when the circuit is broken the heart usually will resume its normal operating rhythm. The feasibility of this method of recovering the heart by an electric counter shock was demonstrated by using experimental animals.[16] It has been applied to man[17] and two cases of successful recovery of the fibrillating heart are reported.

Permanent Effects. Permanent injuries from contact with electric circuits fortunately are extremely rare. Perwitzschky[18] reports 23 cases of auditory and vestibular injuries that appeared either immediately or from one to two years after the shock. It is peculiar that the damage was not related in any way either to the severity of the shock or to the path of the current through the body. There are cases on record where the ear formed one of the circuit contacts yet no permanent after-effects resulted.

Panse[19] and others have reported the development of disseminated sclerosis following electric shocks. In all of these cases no pathological studies are reported, and for the present one must be skeptical of ascribing them to electricity.

Nerve lesions and paralysis are rare after electric shocks, but there are authentic examples. These usually are characterized by muscular atrophy in the extremity through which the current passed. Usually there was pain and weakness following the shock which gradually was transformed into a slow atrophy.

In assessing the value of reports on permanent injuries

one should use considerable critical judgment. These cases are extremely difficult to evaluate because of the great desire for compensation. It is clear that most victims either die immediately or recover, perhaps after extensive burns have healed, without demonstrable neurological damage.

Death from electric shock may result from a number of causes or from a combination of two or more of them. In general, low voltages kill through the mechanism of ventricular fibrillation and high voltages either through the destruction or inhibition of the nerve centers; asphyxia being the immediate cause of death.

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High-Speed Interim Computer

Design and development work supported by the United States Air Force is well under way at the National Bureau of Standards for the construction of a small-scale electronic computing machine to be used until the several large-scale machines now being built become available. The new high-speed machine, to be known as the NBS Interim Computer, will perform as substantial portion of the computation work of the bureau's laboratories, solving many problems until recently considered impossible of solution. It also will aid in computing machine development at the Bureau and will provide important training and operational experience for personnel of those agencies that plan to operate the more complex electronic computers as soon as their construction is complete.

The National Bureau of Standards is now engaged in an extensive computer program, undertaken in co-operation with the Office of Naval Research, the Bureau of the Census, the Department of the Army, and the Department of the Air Force. This program involves the research, design, and development work necessary to produce electronic machines that will perform, upon instruction, predetermined sequences of calculation running into the thousands of operations without the intervention of human operators. The result will be the solution in a few hours of complex problems in atomic physics, ballistics, and aerodynamics which cannot now be solved except by simplifying assumptions and thousands of man-days of work. The rapidity with which numerical data can be handled, classified, and analyzed also will be correspondingly increased.

These new large-scale electronic computing machines are being eagerly awaited. However, because of their complexity, their construction is a long-range project. Meanwhile, by scaling down certain features of a larger machine, such as the high-speed memory, the bureau expects to assemble within a few months a machine capable of solving many of the less complicated problems that continually arise in scientific work. Such a small-scale computer will be quite adequate for routine computations similar to those now being performed in the Computation Laboratory of the bureau's Applied Mathematics Division. Moreover, it is expected to increase present knowledge of maintenance and servicing problems related to electronic digital computers and will be invaluable in many other ways as a test model and research instrument.

Plans are also being made by the bureau for the design and construction of another automatic computing machine for its West Coast laboratory, the Institute for Numerical Analysis. Present indications are that the high-speed memory for the machine will be of the electrostatic type based on the standard cathode-ray-tube memory device developed at Manchester University in England. This project not only will provide a more powerful computing facility at the Institute for Numerical Analysis but should furnish also an excellent opportunity for the study of the parallel type of computer.

The Magnetic Properties of Stainless Steel

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STEELS containing varying amounts of nickel and chromium have been found to be resistant to chemical corrosion and oxidation, and for this reason are grouped under the general name of stainless steel. Little thought was given to their adaptability in electromagnetic circuits, as it was a generally accepted fact that most of the nickel-chromium steels were nonmagnetic or relatively poor in magnetic characteristics as compared with silicon steel. However, the manufacturers of solenoid valves encountered so many valve failures in attempting to use regular steel in valves exposed to acid vapors, that they were forced to resort to the magnetically inferior stainless steels. As this is a highly specialized use of stainless steels, it was not surprising that none of the steel companies had available data on their magnetic properties.

In order to avoid excessive fabrication cost, the valve manufacturers had been using solid stainless steel sections instead of laminated pieces. This meant a large percentage of the over-all heat losses in the valve would be due to eddy currents. Without any data indicating the magnitude of this eddy current loss, the valve designers had no way of knowing whether the reduction of losses by laminating would offset the additional cost. This meant that the test specimens for this investigation had to be of about the same cross-sectional size as the finished valve piece; approximately a one-half inch square.

Six different types of the more common stainless steels were obtained for this research from the Carpenter Steel Company of Reading, Pa. A special analysis of the chemical content of each of the samples and an accurate record of all heat treatments was made. Sample *A* was type *416;* *B* was type *446;* *C* was type *430F;* *D* was type *430;* *E* was type *410;* *F* was type *443.*

Digest of paper 48-275, "The Magnetic Properties of Stainless Steel," recommended by the AIEE basic sciences committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS.*

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An extensive investigation of the magnetic properties of these solid stainless steel samples was conducted. The analysis included d-c and a-c magnetization curves, hysteresis loops, and core losses. These tests were performed over a range of −70 degrees to 600 degrees Fahrenheit.

In Figure 1, the d-c magnetization and permeability curves for sample *A* are shown for various temperatures. The data at −70 degrees Fahrenheit coincided so closely with those at room temperature, that they had to be omitted from the figure. The total core losses per pound plotted against flux density is shown in Figure 2. This test was conducted at 60 cycles.

From the results of these tests and similar experiments, it is to be concluded that the smaller the percentage of chromium present, the more magnetic the stainless steel will be. Those steels with the low chromium content of about 12 or 13 per cent also had a much higher residual magnetism. An examination of Figure 2 will show that the low chromium content stainless steels, sample *A* and *E*, had a lower core loss per pound than the other types. Steels can tolerate up to two or three per cent nickel without serious detrimental effects on their magnetic characteristics. Steels having in excess of eight per cent nickel are nonmagnetic.

As seen from hysteresis loops, the product of the residual magnetism and the coercive force is considerable, and hence stainless steels make fair permanent magnets. In order to counteract this permanent magnetism, it was necessary to insert a small spring in the solenoid valve opposing the electromagnetic action. When the energizing current is shut off, the spring overcomes the residual magnetism and snaps the plunger back into its normal position.

The core losses shown in Figure 2 were separated into their component parts. The eddy current losses in the solid plungers were so great that heat would be radiated into the coil and cause the temperature rise to become excessive; hence, laminations, although expensive, were quite necessary.

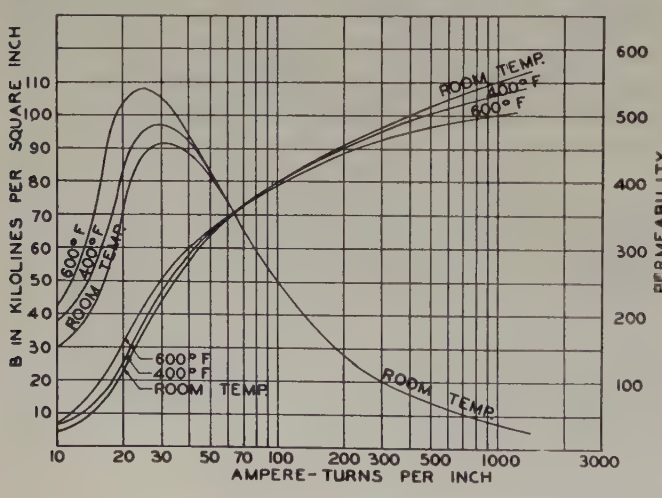

Figure 1 (left). D-c normal magnetization and permeability curves, sample A, at room temperature, 400 and 600 degrees Fahrenheit

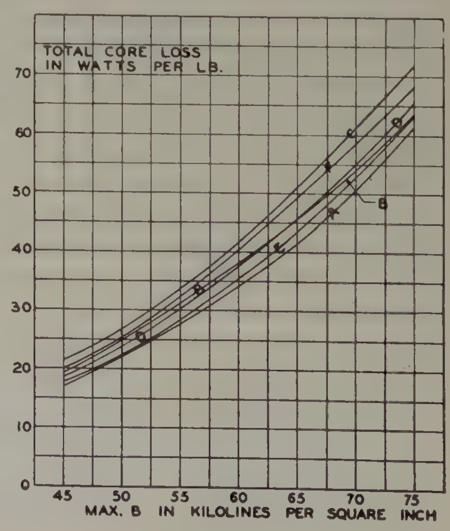

Figure 2 (right). Total core losses per pound, all six samples, at room temperature and tested at 60 cycles

Engineering for Appliances

CARL F. SCOTT
FELLOW AIEE

Several thousand electrical engineers are engaged in the many problems associated with day-to-day production of electric appliances for the home so as to keep up with the public taste in style and appearance. This article deals with many of their highly complex engineering problems involved in designing and building these domestic appliances.

THE electric appliance business for the American home is big business. Eighty-million appliances for the home and farm, worth five billion dollars, are sold annually, utilizing 25 million motors. To keep these appliances in operation, nearly 50 billion kilowatt-hours are delivered by the public utilities, which is more than 20 per cent of the total electrical output of the United States and brings in 33 per cent of the revenue.

The rapid growth of this electric appliance business is shown in the graph of Figure 1. The rate of increase over the past decade has been twice that of the preceding decade. It is a tribute to the engineering and manufacturing talent of this country that the average price of electric appliances for the inflation year of 1947 was only 36 per cent more than for 1936—a far lower increase than experienced in food and other items in the cost of living.

The growth to be expected in the next decade is indicated in an estimate presented by C. A. Powel at the Midwest general meeting in Milwaukee, Wis., October 18–22, 1948. The figures are the number of billions of kilowatt-hours to be used by five classes of customers:

Customer	1947	1957	Per Cent Increase
Residence	41	82	100
Farm	9	22	145
Small industry and commercial	38	58	52
Large industry	115	194	69
Commercial	16	18	13
Total	219	374	71

It is the purpose of this article to touch on some of the technical aspects in the design of domestic appliances and to point out a few of the unsolved problems which will confront the coming generation of engineers.

Lighting, which is still the most important home use of electricity, constitutes today a comparatively small percentage of the total domestic load. Lighting and radio will be omitted from this presentation; it will be confined to motorized appliances, those using electric heat, and kindred applications. Only a few types of appliances are cited in these pages and the problems presented are representative ones.

Development of the Engineering Approach. In the early days of mechanical development in this country, the art preceded the science. Clever men made machines and gadgets which worked, leaving it to later arrivals to find out how and why they worked and to make the analytical studies which have led to modern refinements of design. Ingenuity is still as necessary as ever, but is no longer the sole method of approach. The speed of progress in this atomic age and the keen competition for a share in this enormous market require a high degree of technical preparation.

The designer of appliances draws on a very wide field of engineering. Not only is there a large amount of electrical and mechanical engineering in the ordinary sense but much of chemistry and metallurgy. The large quantities involved have made attractive the setup in manufacture of many processes formerly considered highly specialized. A modern appliance factory besides the usual machining and assembly departments may include within its own boundaries the making of castings by any one of a variety of methods as sand casting, die casting, permanent mold casting; the formulation, extrusion, and molding of plastic materials; the cutting of gears or their formation by other methods such as molding or die casting; the formulation, application, and final treatment of all types of finishes, including vitreous enamels, organic enamels, and all types of electroplating. The influence of all these processes on

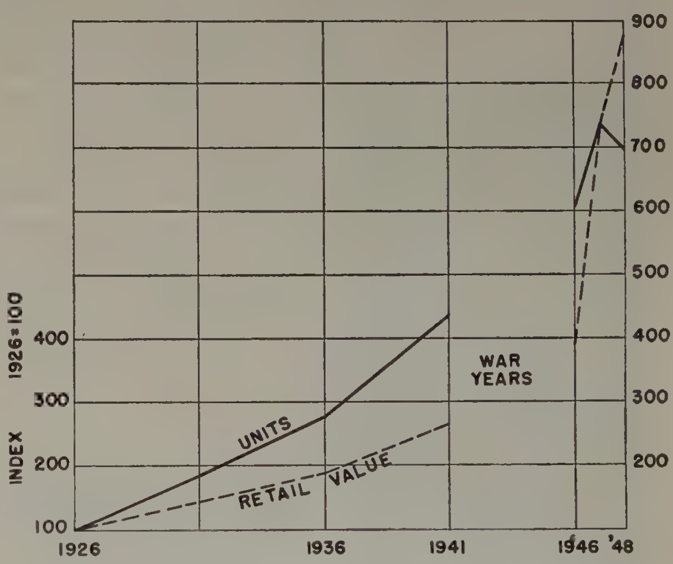

Figure 1. Growth of electric appliance business

Full text of conference paper, "Engineering for Appliances," recommended by the AIEE technical program committee for presentation at the AIEE winter general meeting, New York, N. Y., January 31–February 4, 1949.

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design and on quality are so profound that to do his job the appliance engineer has to cover a very wide field.

The first domestic electric appliances naturally enough looked like the nonelectric ones previously used. In the same way the first automobiles were carriages with engines added. The method of approach was the normal, logical result of ingenious thinking without risk of too much scientific revolution. It has taken time to completely recast the design and appearance to use electric energy effectively.

High-Frequency Cooking. At the present moment revolutionary approaches to some of these problems are in the making. A noteworthy example is the cooking of food in a high-frequency field. At first glance this seems a fantastic complication for use in the home. Right now, a high-frequency cooker is far more expensive than an electric range, and though widely publicized in the last few years, is not yet perfected. However, a simple calculation will show that from the standpoint of cooking efficiency it may not be fantastic. A roast of beef, roasted in the oven of an electric range, is brought to an internal temperature of around 150 degrees Fahrenheit, with the outer skin raised in temperature to something over 400 degrees Fahrenheit. Considering the specific heat of the material and its weight, the actual energy received by the roast will be found to represent something like 10 per cent of the watt-hours drawn from the electric circuit. When a roast is placed in a high-frequency field where the energy is absorbed largely inside the material, one could afford a conversion efficiency of say 35 per cent between the incoming 60-cycle circuit and the magnetron loop which excites the standing-wave oscillations in the cooking cavity, and still have a chance to equal the efficiency of conventional methods, so far as power bills are concerned.

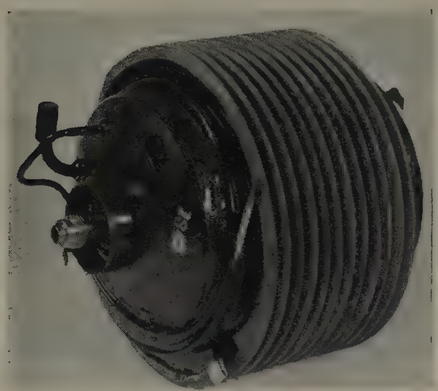


Figure 2. Power unit for domestic refrigerator including the motor and compressor

However, such a roast would not meet consumer standards of taste if dependence were placed solely upon the high-frequency cooking. The outer skin would not have been raised to the point of conversion of the tissues, as the meat would be no hotter on the outside than in the center. There would tend to be a greater loss of the internal juices. Furthermore, in the present state of the development, there is difficulty in getting uniform heating. The wave length of oscillation in the cavity enters into the picture and care must be taken to avoid nodes of minimum energy. There is a large change in energy absorption with the changes in dielectric constant that follow the change in moisture content, dry tissue having a much lower dielectric constant than water.[1]

Successful demonstrations have been made of high-frequency cooking on a wide variety of products, and especially in the defrosting and heating up to a palatable temperature of precooked and subsequently frozen meals or dishes containing mixed meat and vegetables. However, a large number of problems await solution. It is quite possible that this particular application of electric heating may be used first commercially before it is used in the home. There are plenty of examples in mechanical history where this sort of thing has happened. Motor-driven refrigerator units were used commercially before they were used domestically; centrifugal extractors were used in commercial laundries before they were introduced into home washing machines.

Range Surface Units. Following the practice of the coal stove with its hot surface on which a frying pan, stew pot, or tea kettle is used in the preparation of a part of the family meal, electric ranges have evolved very efficient hot surfaces. Beginning a half-century ago with open coils of resistance wire set in bricks of refractory material, there has evolved the long-life enclosed unit, a real scientific achievement. The heating wire itself is made under controlled conditions to secure maximum freedom from unwanted impurities in the form of undesired elements. The wire thus can be operated at a high temperature and hence be a more efficient source of radiation and conduction. The outer sheath in the tubular form of element is another metallurgical achievement, an alloy capable of long continued operation at red heat with negligible corrosion from the influence of the atmosphere or any of the spilled material in the kitchen. Between the heat source and the sheath is a highly purified metallic oxide (usually magnesia) characterized by relatively good thermal conductivity. The whole assembly is put together in automatic machinery and is sealed in glass against the entrance of moisture. Such minute particles of moisture as may have been trapped in the assembly process find their way by chemical combination into inert residues. The result is a very long life, even when wire sizes fine enough to stand operation at 240 volts are used. A simple switching scheme affords a wide variety of "heats" for different cooking operations.

However, this very dependable cooking unit still falls short of an ideal device. The housewife can put a roast or a cake in the oven, set the dials of a timer, leave the kitchen or even the house, and in due course the cooking operation has been started, carried through at proper temperature, stopped and kept warm pending her return. Not so in the case of cooking done on a surface unit. It is not possible to put slices of bacon in a frying pan at night and have them automatically cooked to just the right extent and turned over without intermediate attention.

There are several other automatic cooking devices besides the oven and the electric roaster. There is the automatic coffee maker, the automatic toaster, and the egg cooker; but still there are many unsolved problems in the way of automatic controls for cooking operations.

Electronic Bombardment of Food. Use of the high-frequency field for cooking suggests another electronic application which has been described recently in the literature[2] in the matter of preservation of food by bombardment with high-energy electrons. It has been claimed that meat, for example, subjected to such radiation in air has kept in good condition for a long period of time at ordinary temperatures and without refrigeration. This treatment of food substances for the destruction of bacteria that causes decomposition is too new a field of investigation to warrant drawing any conclusions, but the possible effects are certainly intriguing. The action of X rays on animal and vegetable tissue has been explored by many investigators. The mechanism appears to be one of ionization, the complex molecules of living matter being so altered as the result of the bombardment by X rays as to change their chemical and biological character. The same effect can be produced by radiation by electrons with an efficacy perhaps a thousandfold greater. However, because of the much lower penetration of electrons, deep-seated effects hardly can be expected except with electron beams of very high energy. Such beams, projected into air, involve much the same problems in screening personnel against harmful radiation as is customary in X-ray techniques. The time is probably distant, therefore, before the housewife will exchange her home freezing unit for a five-million-volt electron gun.

Refrigerators. In the field of motor-driven domestic appliances, perhaps the most significant trend today is the increasing number of built-in and totally enclosed motor applications. The hermetically sealed refrigerator unit, Figure 2, now more than 20 years old, was a bold but logical step. Motor and compressor operate together in an atmosphere of refrigerant vapor and finely divided oil particles from which all air and water vapor has been excluded. All the materials both organic and inorganic of motor and compressor must be chemically inert to this peculiar environment. The insulation must never degrade with time with the evolution of water vapor. This rules out most ordinary insulating materials.

Constant refinements of engineering design and improved handling of the disposal of the surplus heat generated in the motor have reduced the size and increased the efficiency of hermetically sealed refrigerator units until today they are in very small packages, and consume an almost negligible quantity of electricity per month. Further progress in the direction of smaller units is of course possible but the curve of diminishing proportions probably will prove asymptotic, and increases in refrigerator shelf area must look to other elements of the design, including the cabinet wall thickness, rather than to much further decrease in compressor size.

Leak Detectors. With this hermetic unit the problem of sealing against leaks is one associated with pipe joints and with condenser and evaporator assemblies, as well as the compressor itself. New developments in the laboratory, one a revival of an old scheme and the other closely identified with recent nuclear physics developments, have proved of great service in the detection of leaks. For the first of these, years ago it had been demonstrated that in an ionic discharge in air at potentials less than that of breakdown between electrodes, the presence of minute quantities of chlorine or fluorine would bring about a marked increase in the ionic current. This principle, rediscovered and reduced to a practical device, now makes possible the detection of very minute quantities of escaped refrigerant, which might leak through the joints in the piping or other parts of a refrigerator system in quantities too small to be detected by other methods.

The second device is an adaptation of the mass spectograph used with such spectacular results in the separation of isotopes. In this application the evacuated compressor unit, prior to the introduction of the refrigerant, is connected by suitable tubing with a small mass spectograph. Helium at atmospheric pressure is sprayed around the outside. The pressure is from the outside in and the helium diffuses into the evacuated chamber through cracks through which air would pass much more slowly. The presence of extremely small quantities of helium are quickly detectible in the mass spectograph. Leaks can be located accurately by this method.[3]

Built-in Motors. The example set by the first hermetically sealed refrigerator units was rapidly followed in the industry and has been applied now to almost all domestic models and to a considerable number of commercial units. What is not so generally appreciated, however, is the influence which the hermetic unit has had in other motor-operated devices. In Figure 3 is shown a totally enclosed power unit for an automatic clothes washer including a motor and a transmission system capable alternatively of reciprocating the shaft, which projects

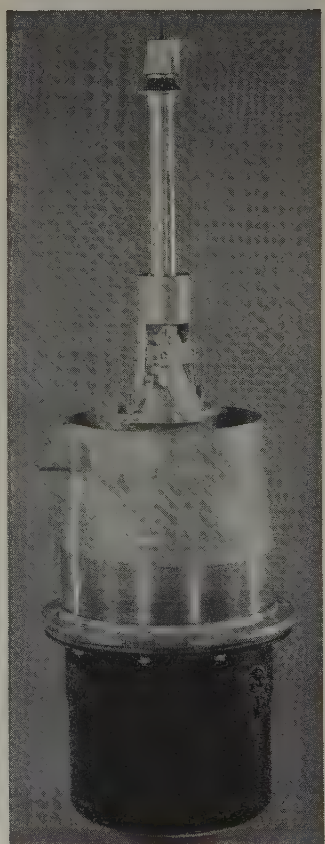


Figure 3. Power units (right) for automatic clothes washing machine including motor, activating and spinning mechanism and (below) automatic dishwashing machine

from the top of the unit, at around 60 strokes per minute for washing and of running it at 1,000 rpm in one direction for extracting the water from the clothes. This totally closed unit includes a clutch, a brake, a device to limit the accelerating torque automatically, and its own self-contained hydraulic system. A small oil pump at the bottom of the shaft circulates oil up through the mechanism with

Figure 4. Power unit for garbage disposal machine (shows rotating elements of shredder, but not inlet housing)

a dual function of operating the clutch and brake by hydraulic means and of lubricating the moving parts. The oil does further duty by flowing back over the motor, carrying off the heat, and transferring heat to the walls of the unit. The casing of the unit is so located that its outer surface is in contact with the wash water, which in turn keeps it cool.

This unit is not hermetically sealed because there is a shaft running through it which requires an oiltight and watertight seal, but it comes pretty close to being a hermetic unit.

Figure 3 shows a unit motor assembly for an automatic dishwasher. Here, also, the motor forms an integral part of the very simple operating mechanism which consists merely of an impeller or dasher with unsymmetrical blading. The impeller revolves in the water in the bottom of the tub and throws the water, with detergent in solution for washing and without detergent for rinsing, against the dishes. The power unit shown in Figure 3 is bolted to the bottom of the tub, with the shaft-housing projecting through. The impeller is not shown in the figure but the blades of the very simple built-in drain pump are shown. The entire lower part of the motor is open for ventilation and so effective is this that the size has been reduced at the same time that the rating has been changed from intermittent to continuous.

Figure 4 shows still another built-in motor application, the totally enclosed garbage disposal unit. In operation, water (containing waste materials) flows over the upper bearing housing (not shown), the control being arranged so the motor cannot start before water flow is established. Figure 4 shows the revolving disk of the shredder elements of very hard alloy steel.

Each of these four motors, for the refrigerator, the clothes washer, the dishwasher, and the disposal unit, are in a sense special motors. Each at the point of motor manufacture consists only of a stator and a rotor without shaft. But the very large volume in any one model, combined with the advantage derived from the mechanical construction of the appliance, have made this so-called special motor best both from an engineering and cost standpoint.

All four of these motors are of the single-phase split-phase type. Three of the four motors use the same diameter rotor and stator punchings. The refrigerator motor is designed for relatively low-starting torque and high efficiency. Low hours use per year of the other three appliances justifies some sacrifice in efficiency, with greater emphasis on starting and accelerating torque. Starting torque requirements on the automatic clothes washer and disposal motors dictate the use of a capacitor in the start winding circuit, but this is not needed in a clothes washer of the conventional wringer type.

There have been significant improvements in recent years in the design of these motors for dissipation of heat losses and in the effective use of the active iron. Improvements in processes at the steel mill combined with proper heat treatment in the motor plant have made it possible to use low-cost steels, at higher saturations than in the past without excessive losses. The output per cubic inch of total material is considerably greater than a few years ago. Every advantage is taken of the operating requirements. All motors must have a certain limit to the starting current, otherwise there would be objectionable blinking of the lights, but this limit can be higher in a washing machine where starting is less frequent than in a refrigerator.

Use of Higher Speeds. The use of high speeds naturally suggests itself as a way to reduce the weight and cost of motors on domestic appliances. Some work already has been done in this direction. Many vacuum cleaner motors today are run at around 15,000 rpm where before the war speeds were about two-thirds of this value. Efficient designs could be made with speeds much higher than 15,000 rpm but there are still problems of brush life which have not yet been fully solved for commutators of very high rotational velocity, not to mention the problems of getting a good balance and of keeping down the noise. Few appliances using induction motors make use of speeds higher than 1,800 rpm on 60 cycles. With modern manufacturing techniques, lower costs can be achieved with 2-pole induction motors but there are many related problems. Refrigerator compressors at this speed obviously must require unusual accuracy and the most careful details in lubrication if a life equal to that of the 1,800-rpm machines is to be secured. Conventional washing machines using a worm gear reduction of about 30:1 usually employ a double-thread worm with a reasonably large helix angle. Change to a single thread worm with a very small helix angle, as would be necessary with a 3,600-rpm motor, shifts the operation into the low-efficiency region with the resultant problems of increased wear, shortened life, and increased energy-consumption, but here too is an interesting problem.

Many suggestions have been made that some form of frequency converter should be installed in the home so that there would be a convenient source of 400-cycle energy for operating appliances, tools, and so on. Of

course, this is perfectly possible but rather expensive at the present time.

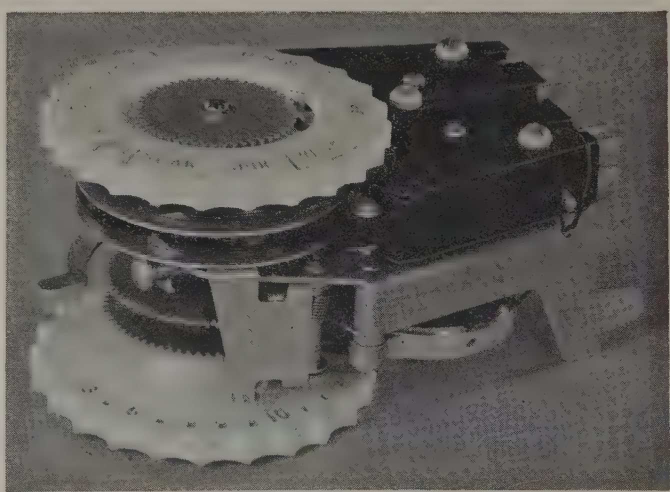
Electric Razor Motors. The electric razor affords an interesting illustration of the development of a motor quite outside the pale of conventional manufacture. At least two of the largest builders of electric razors make use of a motor of a type that might have been scorned by a power engineer a half-generation ago, yet there are millions in successful use today. Here is a motor with a single field coil of extremely simple form readily adaptable to machine winding and capable of being impregnated for resistance to dirt and moisture. The rotor is the simplest possible, a single piece of iron. The contact-points with their rapid make and break, essential to the operation of the motor, present the most important problem and associated with these are the problems of adequate springs, satisfactory wear-life on the cam, and perhaps as important as anything, long life in the little capacitor which is shunted across the contacts. Perfection of this little motor is an engineering achievement of no small size, undertaken and carried through by the razor manufacturers themselves.

Speed Control. The problem of speed control in motors for domestic appliances has presented some interesting problems. Generally, speed control has been avoided. In some instances, however, this avoidance has been primarily in the interest of simplicity and low cost rather than because constant speed is inherently desirable. The pole-changing single-phase motor is expensive and mechanical speed-changing devices are expensive also. Some use has been made experimentally of fluid couplings as speed-changing devices. In one form, so far only in a laboratory model, speed control was obtained with a constant-speed motor and a small fluid coupling in which the volume of oil circulating between the two parts could be adjusted at will. In another form, applied to a washing machine with a centrifugal dryer for extracting the moisture, a fluid coupling has been applied with a rather steep speed-torque characteristic so that if the load is excessive due to unbalance, the speed will be automatically diminished.

Series motors offer a ready means of changing the speed. Motors on kitchen mixers have had variable speed for a good many years. At one time, the principal method was by splitting the field windings and connecting in a weak field which would reduce the torque and lower the speed when low speed was desired. This same method has been applied to vacuum cleaner motors. Another method is to shift the brushes. Because of the relative small size and infrequent service the imperfect commutation which arises in a brush-shift control does not seriously affect the life of a motor. The preferred type of speed control is the centrifugal governor. In this device the main motor circuit is opened when the speed exceeds the preset value, and this preset value is manually adjustable at different speed levels. When the contacts are open by the centrifugal device a resistance is inserted so that the circuit is not completely interrupted and a capacitor also is connected in shunt across the contacts. A device of this sort maintains the original speed-torque curve of the motor and so gives the full maximum power at low speeds. The maximum speed is limited by the governor according to the setting; besides giving variable-speed control, the limitation on the maximum speed prevents runaway at light loads and so reduces the noise. Many forms of governors have been devised and some of them are excellent assemblies of great simplicity and reliability.

The Electrostatic Wind. The electric fan often is described as the first motorized electric appliance to be used in the American home. Electric fans date back at least to the early 1890's. An intriguing method of moving air without a motor is the so-called electrostatic wind. It had been observed 50 years ago[4] that in a silent discharge between electrodes in air, at voltages just a little below the breakdown point, a draft of air was perceptible. By a suitable arrangement of electrodes, within a tube open at both ends (and this is not the only workable arrangement) silent discharges at potentials in the neighborhood of 10,000 volts can produce quite measurable air velocity through the tube. If the air is colored with a little smoke, for example titanium tetrachloride fumes, the effect is quite spectacular. The efficiency of conversion of the electric energy from the supply line into momentum of the air is very low. It is quite low in a small desk fan but the efficiency of the

Figure 5. Motor-driven timer for an automatic washing machine (below), showing (left, above) the assembly of its two column-spring switches and (right, above) its synchronous inductor motor



electrostatic wind is less than one per cent in a small scale laboratory experiment as here mentioned. Several patents were issued in this field between 1934 and 1941.

Circuit Control. A very important phase of appliance engineering is that of electric circuit control. With appliances tending more and more towards complete automatic operation, a number of automatic control devices have to be introduced. These may be responsive to temperature, pressure, time, or some other influence, or a combination of these. Devices of this sort in the field of larger apparatus, where size is not a serious factor, have been engineered in great variety and with a high degree of dependability. The problem in domestic appliances is to make these appliances function with equal dependability, to function in the face of no maintenance, or what may be worse—clumsy maintenance, and to cost a few cents. That is a real accomplishment, and even though much has been done, still more remains to be done.

A manually operated switch for closing a circuit is a pretty dependable device, or at least there are plenty of completely dependable switches available. One reason for this is that the mechanical forces that one must apply are ample to allow for relatively high contact pressures and for sliding contacts under friction high enough to keep them continually clean. On the other hand, contacts operated automatically by bimetallic blades or springs in a large majority of cases are brought through a point of zero pressure at the times of make and break and this tends towards contact troubles.

Various methods are recognized for producing a snap-action in a thermostat on opening and closing, as for example, by an over-center stressed blade or by the use of a permanent magnet. A particular design of automatic flatiron thermostat that has been very successful employs neither of these two devices to obtain snap-action and is of the slow make or break type. It is designed for considerable force and deflection at the operating points. Self-heaters are often incorporated in domestic thermostats to increase sensitivity, decrease temperature differentials, and give an anticipatory control. Differential bimetal elements are often necessary. Nor can the possibilities of thermistors be neglected.[5] The field of thermostats is almost a whole branch of engineering in itself.

Switches used in sequencing of automatic operations in a domestic appliance have tended recently to take the form of unit-switch assemblies, each with its operating button, the button in turn being actuated by a cam of some sort. These switch assemblies, in several forms, involve some form of over-center spring and may function with a very small movement of the operating button. Most such designs, however, have been characterized by a region of low contact pressure at the moment of make and just before the break. A related but basically different principle is that of the column spring illustrated in Figure 5. In this type of device the contact pressure builds up to a maximum just before closing and again just before opening. Figure 5 shows an example of four such switch elements in a sequencing timer for an automatic washer.

The motor driving this timer is an interesting example of a fairly new development. The motor is a synchronous inductor type with a small disk-shaped permanent magnet in the rotor and a very simple single coil, concentric with the shaft, in the stator. The magnetic structure aside from the permanent magnet itself is made up of steel punchings with teeth forming appropriate poles. This type of motor is particularly adapted to slow-speed operation and in the timer shown in Figure 5, the motor runs at 300 rpm. It is geared down 300:1 and develops 16 ounce-inches torque at one rpm.

It was pointed out that all four of the unit assemblies shown in Figures 2, 3, and 4 are of the split-phase type. They all require some device to cut out the starting winding after the motor has come up to almost full speed. The familiar centrifugal switch on the motor shaft is obviously impractical in the refrigerator compressor because it would not do to have an electric contact making and breaking device in the atmosphere inside the compressor casing. For other reasons the centrifugal switch is not used on the other three assemblies shown. All, therefore, make use either of an external relay operated by motor starting current or of a starting cut-out incorporated in a manual starting switch.

There are a number of types of accelerating relays,[6] one using a phase displacement, for certain conditions particularly where a single relay is to be used for a variety of different loads. Another type of accelerating relay has no iron in the magnetic circuit at all except a plunger, which is lifted on the inrush current allowing the starting circuit contacts to close by spring pressure. As the starting current falls, the plunger drops, opening the starting winding. The pressure at the relay contacts is very low, around one-half ounce, yet these relays have been through many hundreds of thousands of cycles without failure.

Mercury Switches. The use of mercury switches was introduced early into the domestic field in oil-burner and air-conditioning controls. There is something very attractive about a mercury switch. The contacts are removed forever from dirt, dust, and moisture. Within certain limits, mercury to mercury makes an ideal switching device as any metal from the contacts that may evaporate will recondense back on the contacts. Obviously mercury switches must be operated at currents and temperatures which keep the device as a switch and do not permit its functioning with a sustained arc. A very compact type of mercury switch, designated a mercury button, has two chrome-iron cups separated by a porcelain disk and sealed in glass. Contact is made by a pool of mercury flowing through an eccentric hole in the porcelain separator when the button is rocked about its axis. A small platinum disk welded to the shell insures good electrical contact between the mercury and the outer shell. The button first is evacuated and then filled with hydrogen at about 2-atmospheres pressure. Very extensive use of this device has been made in wall switches for lighting circuits, where quiet operation is desired, but it has not so far found extensive application in appliance controls. A mercury-contact relay characterized by "uniform performance over a long period of unattended life" has been developed for telephone service.

Such a relay would be considered too expensive for domestic appliances in the ampere capacities required, but it represents the type of device which may some day come into household use because of its dependability.[7]

Modulating Control. The methods employed for current control in domestic heating appliances have been principally to carry full current for a variable period of time resulting in an average energy input. An electric oven or a roaster is controlled so as to have either full current or none. The thermal mass of the shell and other parts of the structure smoothes out the heating effect. Electric blankets hitherto have been controlled in this same way. Range surface units, which do not have automatic control, use manual switching to introduce circuit elements of different impedance across one or other of two voltages. An on-off type of control for range surface units has been extensively used in England. The on-off method of control involves making and breaking of the full current with resultant arcing problems and frequently problems of radio interference. It involves careful study of the thermal constants of the system and careful apportioning of the on-off periods. This is particularly true in the case of automatic electric blankets where too long an interval between heat impulses would cause cooling off and discomfort. The problem is relatively easy in the case of a cooking device with a large mass. Many studies have been directed towards modulating control schemes which are theoretically possible but practically too costly. A variable ratio transformer is bulky and expensive, a series resistance is expensive and wasteful. A saturable reactor often proves to be a very satisfactory means of limiting load current under a very small control influence, but even with the most modern of high permeability materials these saturable reactors are heavy, around one pound for 30 watts at best, and are bulky and expensive. Such controls are being applied, however, to domestic heating systems.

Electronic Control. It is only natural that engineers on domestic appliances should explore the possibilities of the various electronic controls. Familiar bridge circuits with vacuum tube or magnetic amplifiers, and with resistances or reactances sensitive to changes in temperature, light, or other influence, have been explored and applied to a variety of domestic appliances. Such devices have tremendous appeal to engineers familiar with electronic applications in communications and in industry, but so far most have been more complicated and expensive than necessary. In due course no doubt some electronic application to domestic appliances will come into widespread use. But often there are simpler, equally dependable, lower cost methods. A recent control for an automatic blanket uses a sensitive bridge circuit for over-temperature protection, but no vacuum tubes are needed to operate the relay which opens the main circuit.

Market Research. No treatment of the field of the appliance designer would be complete without some comment on the influence of market research. Since appliances are consumer goods, the needs and desires of consumers must be appraised carefully if the production is to have the widest acceptance. Where formerly this was largely a matter of a good hunch or keen judgment, today reliance is put more and more upon countless consumer surveys. If you can find out what people are likely to want there is less chance of your going wrong in a large investment. However, the engineer realizes that there would be danger of stagnation if dependence were made only upon consumer surveys. There always has been, and always should be, the imaginative engineer who conceives of a product fulfilling a desire which the public did not have before the finished article was offered. There have been so many cases, especially in American mechanical history, of inventions that first created desires and then created entire businesses.

Quality. The very large volume in which certain types of consumer goods, including domestic appliances, can be manufactured because of the high standard of living of so large a part of our population has both its attractive and its dangerous side. On the one hand, it makes the engineer's job easier because large investment in automatic machinery is possible with consequent lowering of the cost. On the other hand, the risk of an error is tremendous. A mistake in a large volume of appliances, representing perhaps a part costing only a few cents, may result in loss running into hundreds of thousands of dollars if too many articles get in the hands of the public before the mistake is corrected.

Production Engineering. There have been given in this hasty survey a number of illustrative problems to show what has confronted the designer of domestic appliances and some hints of what lie ahead. However, this summary gives a wholly inadequate picture of the total engineering activity in this large field. Several thousand engineers are engaged in the many problems associated with day-to-day production, with new processes, with the development of new materials, with cost reduction, and with the changes necessary to keep up with the somewhat fickle public taste in style and appearance. It is this army of mass production experts that has made our domestic appliances available in 30 million homes and has introduced an army of mechanical domestic servants undreamed of in any other part of the world. As time goes on, the engineering problems of mass production in the face of rising costs have assumed a magnitude fully as important as the engineering problems of the laboratory and development shop where designs of succeeding years are brought to life.

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Pole Fires Due to Insulator Contamination

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WOOD POLES and crossarms of overhead electric lines may become ignited and damaged when the surface of the insulators and wooden parts are contaminated by industrial dirt and exposed to fog or light drizzle. A few pole fires have occurred in the Chicago area under circumstances which gave a basis for further laboratory study. The circumstances surrounding these fires were peculiar in that on similar lines under apparently the same conditions no burning occurred. This prompted an investigation of the various factors contributing to pole burning in an attempt to evaluate the importance of the different variables and to develop means of prevention.

Under controlled conditions in the laboratory a study was made of various types of insulators and pins, using methods of artificial contamination and fogging. On a laboratory setup of pole, crossarm, and insulator, pole fires were produced under conditions of dirt and fog which resulted in burning similar to that which has been observed in the field.

It was concluded that pole fires cannot be attributed to any single factor, but are the result of a combination of factors to be fulfilled simultaneously. The serious type of fire is the "pocket fire." The burning is most often a smoldering without open flames, but the result is a deep "pocket" burned in the pole. The magnitude of current necessary to produce a pole fire cannot be specified. In some tests, fires occurred with currents as low as five milliamperes. In other tests, currents considerably in excess of five milliamperes did not initiate fires. It is not the magnitude of current, but the concentration, or current density at some point, which gives rise to the serious burning. The immediate cause of burning is an arc in a highly stressed area where fuel is present in the form of wood sufficiently dry to burn or from the wood impregnant.

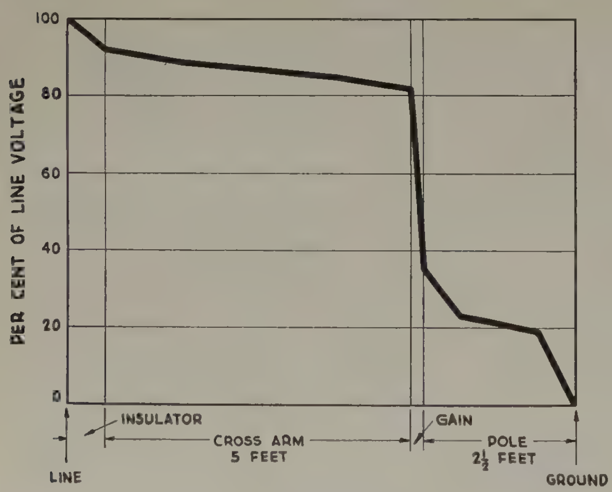

Figure 1. Potential distribution on contaminated fog-wet insulator; arm and pole

Insulator contamination is a requisite for pole burning. However, eight common types of insulators studied on two types of pins in the investigation did not show sufficient differences under conditions of contamination and fog to conclude that pole burning is much more likely with one than with another.

The treatment, or impregnation, of the wood of pole and crossarm is an important factor in the occurrence of fires. Untreated pole wood was found to absorb surface moisture readily and a plentiful supply of moisture was necessary to produce the low resistance and the leakage current necessary for burning. On creosote-impregnated wood, moisture does not penetrate far into the wood and the result is a low surface resistance and high leakage current in fog. The creosote impregnant also furnishes fuel for burning. The occurrence of fires was found to be much more frequent in creosote-impregnated than in untreated wood in the laboratory tests. This is in agreement with field observations of the different behavior, under dirt and fog conditions, of the lines which prompted the investigation. The structures of the lines on which burning occurred were predominantly creosoted wood while the other line structures were largely untreated wood.

Pole fires are most likely to occur at the gain, that is the junction between pole and crossarm, since this is the most highly stressed portion of the wood circuit. The potential distribution curve of Figure 1, plotted from data taken on a setup which had been subjected to fog, shows that nearly one-half of the voltage drop exists in the short section of the circuit represented by the gain. The wood in this region remains relatively dry so the prime requisites for burning, arc and fuel, are present. Most of the fires which occurred in the laboratory tests were found to originate at the gain. Field observations agree with the laboratory results.

An effective method of preventing most pole fires is calking around the gain with a suitable compound. By laying a fillet of plastic compound into the gain lines, the arcs in the danger zone around the gain are eliminated. The total resistance of the wood circuit is not materially reduced and, therefore, the leakage current is not increased. The compound should be soft and adhesive and retain these properties under prolonged weathering. Application of the compound to existing lines, with calking gun, is simple. In laboratory tests the method proved very effective. No fire originated at the gain in any setup where the calking compound was applied.

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Grouped Conductor Surface Voltage Gradients

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GROUPED CONDUCTORS, two or more parallel conductors per phase, have properties which allow their use in a-c power transmission at higher voltages, including: lower surface voltage gradient, directly contributing to lower corona losses; lower inductive reactance; higher capacitive susceptance. To determine by analytical methods the degree grouped conductors affect the conductor surface voltage gradients is the aim of this article. The calculated values of voltage gradients can be used to guide tests on corona losses.

Factors studied that affect voltage gradients at the surface of the conductors are: number of conductors per phase; spacing between conductors of a group; spacing between phases; size of conductors; height of conductors above ground; presence and location of ground wires; instantaneous values of voltages of each phase.

For the smooth single conductor per phase systems, the surface voltage gradient is practically uniform about the conductor periphery, and that single value can be used in corona loss calculations. With two or more conductors per phase, the lines of force between the conductors are distorted resulting in a variable voltage gradient about the conductor periphery. Figure 1 illustrates this flux distortion, for the center phase group of the two, three, and four conductors per group configurations, which results, for the specific example, in a variation between the maximum and minimum surface voltage gradients of between 12 per cent and 15 per cent. It is this variation that needs test results to establish a correlation between actual corona loss and the variable surface voltage gradient, thus:

1. Total cross-sectional conductor area per phase (based on outside diameter of each conductor) has the greatest effect on conductor surface voltage gradients; the greater the total area, the smaller the voltage gradient.

2. Appreciable reduction in surface voltage gradients results with the following, in addition to conductor areas: greater number of conductors per phase, up to an intragroup conductor spacing of approximately 25 inches or more; smaller intragroup conductor spacing down to approximately eight inches, below which the gradient increases; greater spacing between phases.

3. Variation in height of conductors above ground, as practically applied, has almost a negligible effect on conductor surface voltage gradients.

4. Ground wires, as practically applied, increase the maximum surface voltage gradient less than two per cent, and generally one per cent or less. This maximum gradient exists on the center phase group of a horizontal configuration of conductors.

5. The greatest reduction in inductance and increase in capacitance is with increasing number of conductors per phase. Other factors producing this variation to a lesser degree are: larger intragroup conductor spacing; smaller spacing between phases; greater total conductor area per phase.

If total conductor areas per phase are kept constant, and intragroup conductor spacings kept between 12 inches to 24 inches, the reduction of maximum voltage gradients of grouped conductors compared to that of an equivalent area single conductor is moderate. At a 15-inch intragroup conductor spacing this reduction becomes approximately 3, 9, and 14 per cent for two, three, or four conductors per phase, respectively. If the intragroup conductor spacing is 24 inches and more, not more than 10 per cent reduction can be realized with any grouping of conductors up to four in number, and increasing the intragroup conductor spacing to 25 inches or more can result in the maximum voltage gradient of the grouped conductors becoming greater than that of the equivalent single conductor. For a 32-foot spacing between phases and 18-inch intragroup conductor spacing, increasing the area of conductors per phase from 1×10^6 circular mils to 4.0×10^6 circular mils (based on over-all diameters), results in approximately 44 per cent decrease in maximum conductor surface voltage gradient.

The effect of spacing between phases is indicated in the example of a 4-conductor grouping at a phase spacing of 45 feet and intragroup conductor spacing of 18 inches. The reduction in voltage gradient compared to the equivalent single conductor was 15 per cent.

Digest of paper 48-285, "Relative Surface Voltage Gradients of Grouped Conductors," recommended by the AIEE transmission and distribution committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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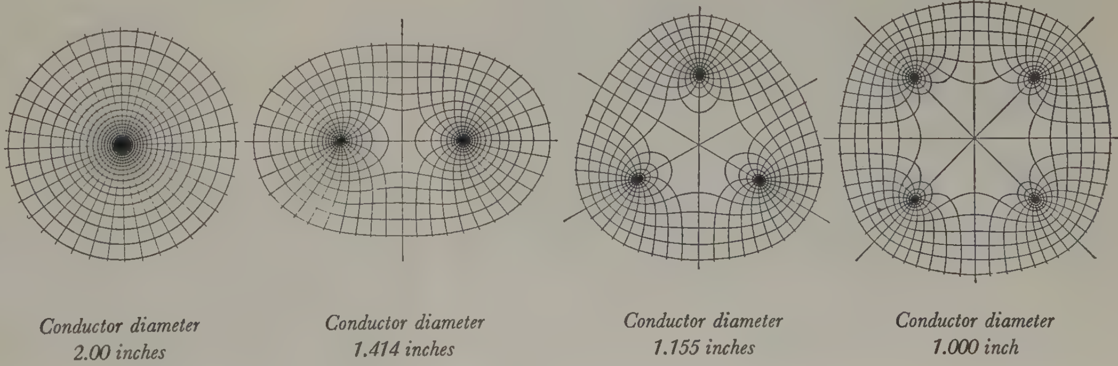

Figure 1. Flux and equipotential lines of center phase group of 1, 2, 3, and 4 conductors, each of a horizontal configuration at time of maximum peak voltage, with intragroup spacing at 18 inches, phase spacing at 32 feet, and 66.7 feet above the ground

Low Frequency Applied to Control Problems

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THE BEHAVIOR of an induction motor under normal conditions of applied voltage and frequency is well understood. The purpose of this discussion is to investigate induction motor behavior when low-frequency polyphase voltages are impressed on its primary, and to consider a means of efficiently generating the required low-frequency voltages. Decreasing the frequency of the voltages impressed upon the primary or stator winding of the induction motor slows the speed of rotation of the air gap flux. The speed of the air gap flux is proportional to the frequency. Decreasing the frequency reduces the motor speed, but has no effect upon the shape of the induction motor's speed-torque curve providing the magnitude of the air gap flux is maintained constant.

Actually it is not practicable to keep the magnitude of the air gap flux constant since this would require an adjustment of the primary voltage to compensate for every change in load. Consequently the following relation has been developed in order to predict the speed-torque relation for any given motor in terms of the impressed voltage and frequency:

$$T=3V_1^2\frac{M_0^2r\omega_2^2}{[rR-\omega_1\omega_2(L_0l_0-M_0^2)]^2+[\omega_1 rL_0+\omega_2 Rl_0]^2} \qquad (1)$$

where

T = average 3-phase torque in synchronous watts (based upon normal frequency)
ω_1 = primary frequency in radians per second
ω_2 = secondary frequency in radians per second
R = stator resistance per phase
r = rotor resistance per phase
L_0 = apparent stator 3-phase self-inductance per phase
l_0 = apparent rotor 3-phase self-inductance per phase
M_0 = apparent 3-phase mutual inductance per phase
$V_1=\dfrac{E_\alpha+jE_\beta}{2}$ positive phase sequence stator voltage

One method of generating low-frequency power is shown in Figure 1. In this scheme, exciter E is a commutator-type generator having a laminated field structure. Its field winding L_0 is connected to its brushes through a capacitor C_0. The constants of the resonant circuit thus formed determine the frequency of oscillation. By using high-capacitance electrolytic capacitors, the generator may be used effectively at frequencies as low as two cycles. Starting is accomplished by means of an auxiliary relay (not shown) which by-passes capacitor C_0 momentarily and allows the generator to build up as a d-c shunt machine.

Polyphase power may be obtained by using the exciter to supply field current I_1 and I_2 to generators G_1 and G_2. These generators are also commutator-type machines similar to the exciter. By adjusting capacitor C and resistors R_1 and R_2, currents I_1 and I_2 can be given a 60-degree phase displacement relative to each other at the desired operating frequency. By "vee-connecting" generators G_1 and G_2, 3-phase low-frequency voltages are obtained at terminals A, B, and C.

Typical output wave forms using standard 1/5-horsepower 32-volt shunt generators without compensating windings are shown in Figure 2.

The performance of an induction motor on low-frequency voltages can be predicted by means of equation 1. Full torque is available from the motor provided the impressed frequency is at least equal to the slip frequency at which this torque normally would occur. The change in speed from full load to no load under the foregoing conditions is about the same as under normal operating conditions.

Small high-speed machines can be effectively employed in generating the voltages needed for low-frequency operation. Although the generating system described is best suited to supplying one frequency, a selection of frequencies and speeds can be obtained by simultaneously switching the low current exciting circuits to provide the necessary change in circuit constants for different frequencies.

Speed control in the manner described is particularly useful in applications requiring several induction motors to be started either individually or simultaneously without immediately accelerating to a high speed. This feature is required in printing press and other drives where a number of individual units are flexibly interconnected. The ease with which these units can be arranged in various combinations is greatly enhanced if they can be driven individually.

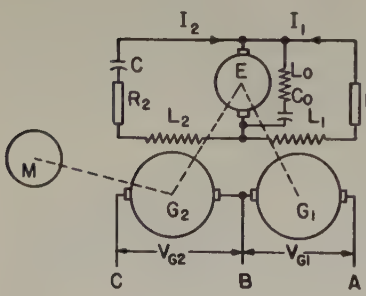
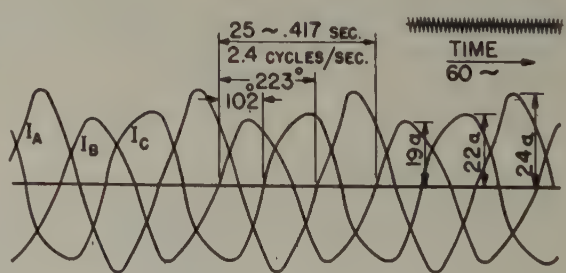


Figure 1. V-connected separately excited generators for 3-phase power (left)

Figure 2. Instantaneous load currents with generators connected as shown in Figure 1



Digest of paper 48-283, "Application of Low Frequency to Industrial Control Problems," recommended by the AIEE industrial control committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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The Transistor—A New Semiconductor Amplifier

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"TRANSISTOR" is the name which has been given to the semiconductor amplifier triode recently developed at the Bell Telephone Laboratories. The prefix "trans" designates the translational property of the device, while the root "istor" classifies it as a solid circuit element in the same general family with resistor, varistor, and thermistor.

This article describes the construction, characteristics, and behavior of the newly discovered device, the transistor. Used as a semiconductor amplifier, it works on an entirely different principle and is capable of performing the same tasks now done by the vacuum tube triode.

A transistor differs advantageously from a vacuum tube in several important respects. It has no vacuum. It has no filament; consequently, it consumes no filament power and requires no warm-up time. It is both smaller and lighter than any commercially available vacuum tube. Within the present limitations of their power handling capacity, noise, and frequency response, transistors can perform many of the tasks now performed by vacuum tube triodes. They have been successfully demonstrated in radio-frequency, intermediate-frequency, and audio-frequency amplifiers, oscillators, mixers, and pulse generators.

The transistor principle was discovered by J. Bardeen, W. H. Brattain, and W. Shockley[1,2,3] in the course of theoretical and experimental studies on the possibility of controlling the resistances of thin semiconductor layers by the application of electric fields strong enough to penetrate their surfaces. In the course of these investigations Bardeen and Brattain found that when two suitably arranged contacts are made to the surface of a semiconductor, the current-voltage relationship of one of them can be altered by the passage of current through the other. The extent of this interaction is such that a small signal introduced into a circuit containing the control contact is reproduced in amplified form in the circuit containing the main contact.

This article describes the characteristics and behavior of two kinds of transistor which have received considerable study at the Bell Telephone Laboratories and which differ from each other in appearance, construction, and electrode geometry. The first of these, the type-*A* transistor, has been made in considerable numbers, and is available for experimental use. The second kind, the double-surface transistor, is still in early-stage development.

Full text of conference paper, "The Transistor, a New Solid State Amplifier," recommended by the AIEE technical program committee for presentation at the AIEE winter general meeting, New York, N. Y., January 31–February 4, 1949.

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CONSTRUCTION OF TRANSISTORS

The type-*A* transistor consists of a small wafer of the semiconductor germanium onto one surface of which two point contacts are made, side by side and close together. These contacts, together with their immediate electric connections, are called the "emitter" and the "collector" respectively, for reasons which will appear later. A large-area contact to the opposite surface of the wafer is called the "base electrode." These elements are assembled into a cartridge which is pictured in full and cutaway photographs in Figure 1. To assist in the understanding of the relationship of the various parts, the longitudinal section drawings of Figure 2 are presented.

In the fabrication of a type-*A* unit a slice of germanium cut from a high-back-voltage ingot is ground flat on both sides, copper-plated and tinned on one side, and diced into small squares with a diamond wheel. One of these squares then is sweated onto the brass base plug which, after the administration of the proper surface treatment[4,5] to the germanium wafer, is force-fitted into the base end of the cartridge.

The contact assembly is made by molding the two support pins into a cylindrical plug of insulating material. The 0.005-inch phosphor bronze wires, which previously have been pointed at one end by bevel-grinding and polishing, are spot-welded to the ends of these pins.

After welding, the wires are bent[4,5] in a jig into the

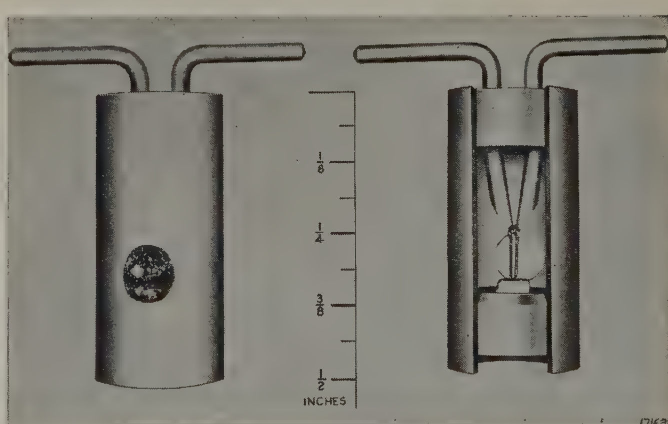

Figure 1. Full-view and cutaway photographs of the type-A transistor

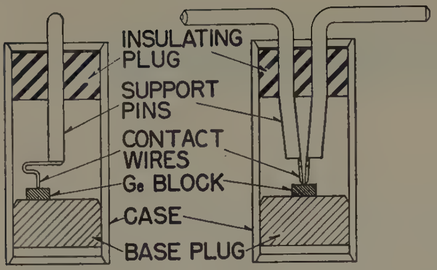

Figure 2. Longitudinal section drawings of the type-A transistor

cantilever form shown in Figures 1 and 2. After a final manual adjustment of the points to equal vertical clearance and specified lateral separation, the assembly is forced into the other end of the cartridge until contact is made between the points and the germanium surface. An additional 0.002 inch push compresses the springs enough to insure that the contact will be permanent under conditions of ordinary use. The cartridge then is wax-filled[4,5] to improve its mechanical stability. After a final electrical forming treatment[4,5] of one or both contacts, the emitter-collector polarity is selected, and the electrode pins are appropriately bent according to the scheme of Figure 3. The metal case is the base connection of the unit. The size of the type-*A* transistor can be seen by comparison with the scale in Figure 1. Its weight is 1.3 grams.

The double-surface transistor[6] differs from the type-*A* device in that the emitter and collector points bear on the opposite faces of a thin piece of semiconductor, to which a large-area base contact also is provided. This form of transistor first was produced with germanium in the shape of an acutely tapered wedge, with the two contacts bearing oppositely near the thin edge. A mounted form of the double-surface transistor is described in a companion article by W. E. Kock and R. L. Wallace, Jr., appearing elsewhere in this issue.[7] In this model the germanium is cut into a pill-shaped cylindrical wafer with a dimple ground into the center of one or both sides, so that the thickness at the center is only a few thousandths of an inch. Here the emitter and collector bear oppositely upon the semiconductor in a coaxially arranged cartridge mounting.

CONVENTION REGARDING SIGN OF CURRENTS AND VOLTAGES

Since transistors undoubtedly will receive considerable attention in the engineering literature, it is desirable that all engineers use the same convention regarding direction of voltages and currents. This matter has been investigated at the Bell Telephone Laboratories by a group of engineers who have made the tentative proposals that: all voltages are to be referred to a common reference, which in this article will be taken as zero for the potential of the base; all currents are positive if they flow in the direction that positive voltages would produce. This convention is illustrated in Figure 4, which shows a schematic diagram of a transistor circuit in which the arrows for currents and voltages indicate positive directions. In most transistors made at the present time E_1, V_1, and I_1 are positive, while E_2, V_2, and I_2 are negative when the transistor is properly biased for class-*A* amplification. Cases have arisen, however, in which this is not true and more such cases unquestionably will arise in the future. This convention, which is consistent with the new proposal for electron tubes being made by the Institute of Radio Engineers, may afford a simple and unambiguous method of describing these cases.

STATIC CHARACTERISTICS OF TRANSISTORS

In a transistor both the emitter and the collector contacts are rectifiers. The emitter contact is operated in the forward or low resistance direction while the collector is operated in the reverse or high resistance direction. When the points are far apart the emitter currents and voltages do not affect the collector currents and voltages. However, when the contacts are near each other, the collector voltage versus current relation is greatly affected by the values of the emitter current or voltage. This interaction is shown for a representative type-*A* unit in Figure 5. This is a plot of V_2 versus I_2 for a series of constant values of I_1 (solid lines) and for a series of constant values of V_1 (dashed lines).

Current is chosen as the independent variable because such a choice simplifies the physical interpretation of the actions in the transistor, the voltages are single valued functions of the currents, and in certain regions of their characteristics, transistors sometimes become unstable when the external terminals are short-circuited to alternating current.

In Figure 5 the solid line for which $I_1=0$ is merely the voltage versus current curve for the collector as a diode when the emitter circuit is open. If a constant positive current is made to flow in the emitter circuit, the resistance in the collector circuit decreases and the curves shift toward larger negative currents. Over a considerable region of the plot, the increase in the collector current for a constant collector voltage is greater than the change in the emitter current producing it. This means that the transistor is a current amplifier with a current amplification factor $\alpha=\frac{\Delta I_2}{\Delta I_1}$ greater than unity. In most units α is approximately 2.0. Occasionally values higher than ten are found. Even if α is only 1.0 or less, power gains still are obtained since the current is transferred from a low resistance circuit to a high resistance circuit.

If the emitter contact is directly connected to the base the V_2 versus I_2 relationship is shown by the dashed curve, marked $V_1=0$. Similarly, if the emitter is connected to the base through a battery having zero internal resistance and a small positive or negative electromotive force, the

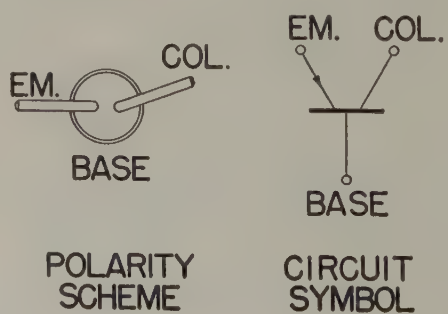

Figure 3. Polarity convention and circuit symbol for type-A transistor

series of dashed curves is obtained. Note that these dashed curves may have negative slopes, indicating negative variational resistance when V_1 and I_2 have relatively large values. This means that for low input and output resistances the transistor may be unstable. Stability can be secured by inserting a sufficiently high resistance in the output circuit. The same result can be accomplished by including a high resistance in the input circuit.

Note that any two of the four quantities I_1, V_1, I_2, V_2 determine the other two. The interrelationship between these quantities can be presented profitably in three other plots describing the same unit. The data for these three plots all are contained in Figure 5. Figure 6 shows curves of V_1 versus I_1 for a series of constant values of I_2. The curve for $I_2=0$ is the forward voltage-current diode characteristic of the emitter contact. This figure shows the influence of various collector currents on the forward characteristics of the emitter. In this case, for a constant V_1, the increase in I_1 is always less than the corresponding increase in I_2; that is, $\dfrac{\Delta I_1}{\Delta I_2}<1$.

Figure 7 shows how the collector voltage varies with the emitter current for constant collector currents. From these curves it is seen that the collector voltage for a constant collector current decreases rapidly for rather small increases in emitter current. This must mean that the resistance near the collector decreases rapidly for an increase in emitter current. As will appear more clearly later, the slopes of these curves measure the forward transfer resistance for a-c currents in the emitter circuit.

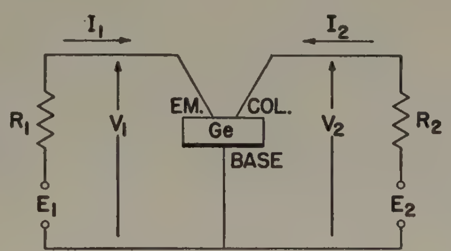

Figure 4. Convention for directions of voltages and currents in transistor circuits

Figure 8 shows how the emitter voltage varies with the collector current for a series of constant emitter currents. For $I_1=0$, the emitter is "floating" and this curve measures the floating potential of the emitter for various values of the collector current. For positive emitter currents, the decrease of V_1 with I_2 is less rapid. The slopes of these curves measure the feedback resistance for small a-c currents impressed in the collector circuit.

LARGE SIGNAL PERFORMANCE

From the data in Figures 5 and 6 it is possible to predict the input current and output current for any electromotive force and external resistance in the input circuit coupled with any electromotive force and load resistance in the output circuit. To do this one proceeds as follows. Draw a load line across the curves of Figure 5 with voltage intercept equal to the electromotive force in the collector circuit and negative slope equal to the load resistance. Draw another load line across the curves of Figure 6 appropriate to the values of external resistance and electromotive force in the emitter circuit. Replot this emitter load line on the collector characteristics of Figure 5. The point of its intersection with the collector load line will be an operating point of the transistor. Changing the signal voltage in the emitter circuit will cause a change in the position of the emitter load line.

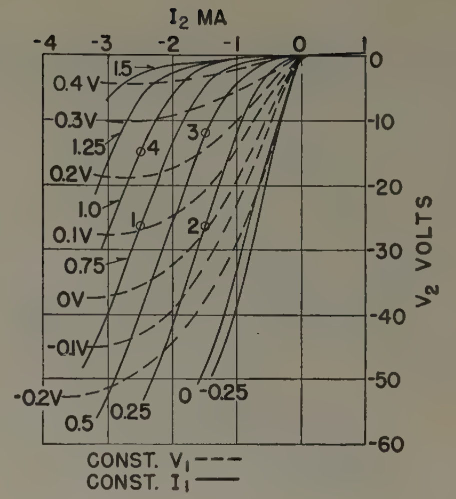

Figure 5. Family of collector characteristics for type-A transistor

By following through with this procedure the corresponding successive instantaneous operating points of the transistor can be obtained. The large signal performance thus can be deduced in a way analogous to that used for vacuum tube performance.

SMALL SIGNAL PERFORMANCE

The small signal performance about any particular d-c operating point can be deduced easily by analysis with reference to an equivalent circuit. From this equivalent circuit the a-c behavior of the transistor can be calculated for any input and output conditions. In particular, equations can be derived for input impedance, output impedance, and power gain.

Since we wish to consider currents as independent variables, we can write

$$V_1=f_1(I_1, I_2) \tag{1}$$

$$V_2=f_2(I_1, I_2) \tag{2}$$

where f_1 and f_2 are functions determined by the experiments from which Figures 6 and 5 are plotted.

By expanding these functions in a Taylor series about

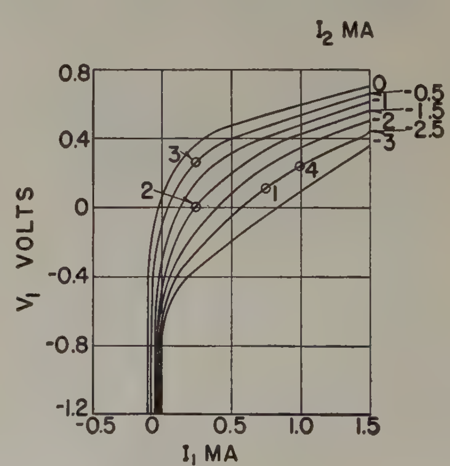

Figure 6. Family of emitter characteristics for type-A transistor

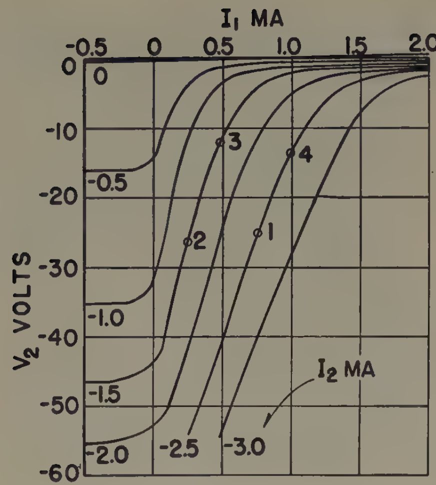

Figure 7. Family of forward transfer characteristics for type-A transistor

any d-c operating point and considering only first order terms, we obtain the following equations:

$$\Delta V_1 = \frac{\partial f_1}{\partial I_1}\Delta I_1 + \frac{\partial f_1}{\partial I_2}\Delta I_2$$

$$\Delta V_2 = \frac{\partial f_2}{\partial I_1}\Delta I_1 + \frac{\partial f_2}{\partial I_2}\Delta I_2$$

In these equations the partial derivatives with respect to one current imply that the other current is kept constant. The partial derivatives have the dimensions of impedances. Therefore, we may write

$\frac{\partial f_1}{\partial I_1} = \frac{\partial V_1}{\partial I_1} = R'_{11}$, the input impedance for a-c open-circuited output

$\frac{\partial f_1}{\partial I_2} = \frac{\partial V_1}{\partial I_2} = R'_{12}$, the backward transfer impedance for a-c open-circuited input

$\frac{\partial f_2}{\partial I_1} = \frac{\partial V_2}{\partial I_1} = R'_{21}$, the forward transfer impedance for a-c open-circuited output

$\frac{\partial f_2}{\partial I_2} = \frac{\partial V_2}{\partial I_2} = R'_{22}$, the output impedance for a-c open-circuited input

In terms of the static characteristics already presented

R'_{11} = slopes of curves of Figure 6
R'_{12} = slopes of curves of Figure 8
R'_{21} = slopes of curves of Figure 7
R'_{22} = slopes of curves of Figure 5

Well-known linear network theory[8] leads to a number of possible equivalent circuits containing resistances and

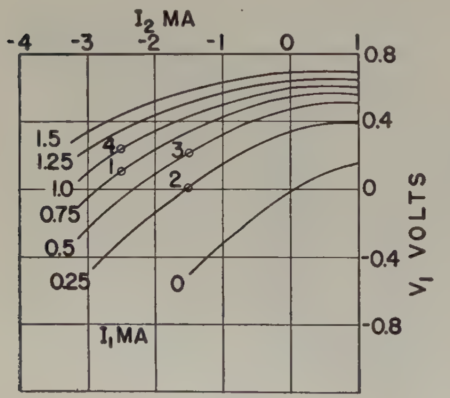

Figure 8. Family of backward transfer characteristics for type-A transistor

internal generators. A particularly useful form of equivalent circuit is shown inside the dashed box in Figure 9. In this circuit there are three resistances: r_e associated with the emitter contact, r_c with the collector contact, and r_b with the base contact. The active property of the network is described by the inclusion of an internal generator $r_m\Delta I_1$ whose electromotive force is the product of the mutual transfer resistance r_m and the variation of the input current ΔI_1. The convention for positive currents and voltages is as shown by the arrows in this figure. The quantities ΔI_1 and ΔI_2 can be replaced by alternating currents i_1 and i_2 whose value is small compared with the bias currents I_1 and I_2. The figure does not show the external batteries and bias currents. v_g is an alternating voltage signal generator in the input circuit.

It is easy to deduce then, that the four resistances in this equivalent circuit are related to the open-circuit input, the output, and the transfer resistances by the following equations:

$R'_{11} = r_e + r_b$
$R'_{12} = r_b$
$R'_{21} = r_m + r_b$
$R'_{22} = r_c + r_b$

From Figures 5 to 8 it follows that the open-circuit resistances and hence the parameters in the equivalent circuit will depend on the values of the bias currents I_1 and I_2. They also will vary from one unit to the next. For a representative type-A transistor in a good operating region the equivalent circuit resistances might be: r_e=250 ohms; r_b=250 ohms; r_c=20,000 ohms; r_m=40,000 ohms. Since transistors are in an early stage of development, appreciable variations from unit to unit are to be expected. As the transistor art develops these variations undoubtedly will be reduced.

The following expressions can be derived from circuit analysis of the equivalent circuit. Numerical examples are given for R_1=500 ohms, R_2=10,000 ohms, and the typical equivalent circuit values have been given in the foregoing paragraph:

$$\text{Input impedance } R_{11} = R'_{11} - \frac{R'_{12}R'_{21}}{R'_{22}+R_2}$$

$$= (r_e+r_b) - \frac{r_b(r_m+r_b)}{(r_c+r_b)+R_2} \simeq 500-330=170 \text{ ohms}$$

$$\text{Output impedance } R_{22} = R'_{22} - \frac{R'_{12}R'_{21}}{R'_{11}+R_1}$$

$$= (r_c+r_b) - \frac{r_b(r_m+r_b)}{r_e+r_b+R_1} \simeq 20{,}000-10{,}000=10{,}000 \text{ ohms}$$

$$\text{Available gain} = \frac{\text{Power to matched load}}{\text{Maximum power available from generator}}$$

$$= \frac{R_1}{R_{22}}\left(\frac{R'_{21}}{R'_{11}+R_1}\right)^2 = \frac{R_1}{R_{22}}\left(\frac{r_m+r_b}{r_e+r_b+R_1}\right)^2$$

$\simeq$80 (or 19 decibels).

Maximum available gain = Available gain when $R_1 = R_{11}$

$$= \frac{R_{11}}{R_{22}}\left(\frac{R'_{21}}{R'_{11}+R_{11}}\right)^2 \simeq 130 \text{ (or 21 decibels)}$$

If r_b is reduced to zero these expressions for impedance and gain become much simpler. Also, the gains become

smaller because of the elimination of the positive feedback supplied by finite r_b. Thus:

$R_{11}=R'_{11}=r_e=250$ ohms
$R_{22}=R'_{22}=r_c=20{,}000$ ohms

$$\text{Available gain}=\frac{R_1}{R'_{22}}\left(\frac{R'_{21}}{R'_{11}+R_1}\right)^2\simeq\frac{R_1}{r_c}\left(\frac{r_m}{r_e+R_1}\right)^2\simeq 71$$

$$\text{Maximum available gain}=\frac{R'_{11}}{R'_{22}}\left(\frac{R'_{21}}{2R'_{11}}\right)^2=\frac{(R'_{21})^2}{4R'_{22}R'_{11}}=\frac{1}{4}\frac{r_m r_m}{r_c r_e}\simeq 80$$

In transistor production it is considered desirable to keep r_b as small as possible, despite the reduction in available gain. This provides a greater margin against instability. Feedback always can be supplied externally when desired.

A family of collector characteristics for a double-surface unit is presented in Figure 4 of the afore-mentioned Kock-Wallace article. The chief point of difference between these curves and those for the type-*A* unit of Figure 5 is in the relative positions of the dashed lines for constant V_1 This difference can be accounted for by the fact that the feedback resistance r_b is about 250 ohms for type-*A* units, while for double-surface units it is around 500 ohms.

Table I. Comparison of D-C and A-C Measurements of Transistor Circuit Constants

Point	I_1 (Milli-amperes)	I_2 (Milli-amperes)	Circuit Constant	A-C Measurement (Ohms)	Slope of Static Characteristic (Ohms)
1	0.75	2.5	R'_{11}	575	525
			R'_{12}	272	288
			R'_{21}	50,000	53,500
			R'_{22}	28,000	25,600
2	0.25	1.5	R'_{11}	925	1,040
			R'_{12}	278	270
			R'_{21}	67,000	73,000
			R'_{22}	31,000	28,000
3	0.5	1.5	R'_{11}	625	580
			R'_{12}	252	240
			R'_{21}	43,400	45,300
			R'_{22}	22,900	20,800
4	1.0	2.5	R'_{11}	520	480
			R'_{12}	266	240
			R'_{21}	46,500	39,500
			R'_{22}	26,400	23,000

COMPARISON BETWEEN PARAMETERS DETERMINED FROM STATIC CHARACTERISTICS AND FROM A-C METHOD

Table I compares the values of R'_{11}, R'_{12}, R'_{21}, and R'_{22} determined from the slopes of the d-c static characteristics with the values determined by an a-c test equipment designed by J. H. Felker for the direct measurement of these quantities. In the latter case the a-c test current was 10^{-4} ampere at a frequency of 5 kc per second. The comparison is given for the four bias conditions indicated by circles in Figures 5 to 8. The agreement is as good as the uncertainty in the determination of the slopes of the curves. This fact justifies the assumptions underlying the network analysis and shows that the equivalent circuit constants are the same at 5 kc per second as at zero cycles per second.

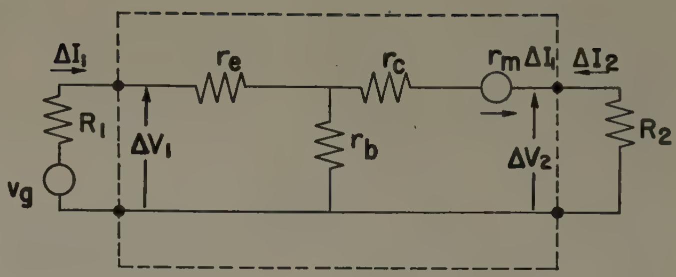

Figure 9. Equivalent T network for describing transistor small signal performance

POWER-HANDLING CAPACITY

A complete analysis of the power delivering ability of a transistor can be made from data of the sort presented in Figure 5. As with vacuum tubes, the maximum useful power obtainable from a transistor is a compromise with allowable distortion. The transistor of Figure 5, operated on a 25,000-ohm class-*A* load line about the biasing point represented by circle number 1, would deliver six to eight milliwatts of useful power with a distortion tolerable in the final stage of an ordinary audio amplifier. In class-*B* operation, typical units of both types deliver 25 to 30 milliwatts per push-pull pair. Occasionally units are found from which 50 or 60 milliwatts of reasonably undistorted power can be obtained per pair.

FORMING TREATMENT

When the two point contacts are pressed first against the germanium they are likely to have similar characteristics, and either point may be used as the collector. In some cases, the emitter current in the forward direction may have only a small influence on the collector characteristics. Transistor action usually can be improved by a forming treatment.[1]

One such treatment comprises passing a relatively large current through the collector point in the reverse direction. The effect of this process is to reduce the reverse resistance of the collector and to increase the influence of the emitter current on the collector characteristics.

NOISE IN TRANSISTORS

In discussing transistor noise, use will be made of a theorem[9] which states that the noise in a 4-terminal network can be considered as originating in two noise generators

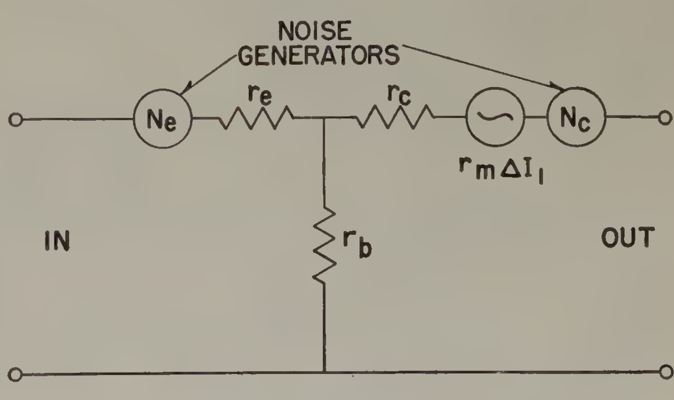

Figure 10. Transistor noise equivalent circuit

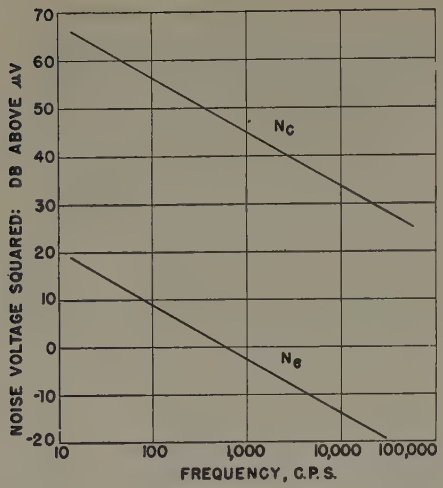

Figure 11. Noise versus frequency plot for a typical transistor

included in two of the arms of the network, whose other components are regarded then as ideally noiseless. In the transistor equivalent network already developed, the two generators will be considered as voltage generators, placed in the emitter and collector arms of the circuit, as shown in Figure 10. A generally satisfactory specification of transistor noise now can be made by giving the noise voltage N_e and N_c of these two generators per unit band width, the dependence of these voltages on frequency, and the magnitude and phase of any correlation existing between the voltages.

In making measurements of these quantities, the transistor under test is biased to a d-c operating point previously selected for good amplifier gain performance. The biases are applied through chokes having practically infinite impedances at all frequencies of testing interest. The open-circuit noise voltages then are measured directly by placing a narrow-band voltmeter, such as a General Radio wave analyzer, across the input and output terminals in turn. The frequency dependence of the noise voltages is obtained by sweeping the frequency spectrum with the pass band of the voltmeter. Measurements on the correlation between N_e and N_c have been based so far on the challengeable assumption that, at least at low noise frequencies (~1 kc per second), any correlation between the two would be either wholly in phase or wholly in opposition. The voltages N_c and N_e are amplified until their rms amplitudes are equal; the two instantaneous voltages then are added, under conditions such that the impedance to each is the same as when each was measured separately, and the resulting rms voltage is observed. If N_e and N_c are completely random and no correlation exists, the voltage sum would be $\sqrt{2}$ times either one alone. For 100 per cent correlation with zero phase difference the voltage sum would be twice either voltage alone, and for 100 per cent correlation with 180 degree phase difference the sum would vanish.

Measurements of some of the foregoing noise quantities have been made for about three dozen transistors, including individuals of both types. Typical values for the noise voltages are N_e~1 microvolt and N_c~100 microvolts in a band of unit width at 1,000 cycles per second Most of the units measured have noise voltages falling between one-third and three times these values. A generally accepted measure of noise performance in an amplifier is its noise figure, defined as the ratio of the noise power actually available from the output terminals to the noise power which would be available if N_e and N_c were both zero and the only contributing noise source were thermal noise in the input signal generator. For transistors with typical impedances and gain properties operated in typical circuits, the noise figures for a narrow band centered at 1,000 cycles per second run from 55 to 70 decibels. Various ways of reducing the collector noise of transistors have been suggested and tried, some with success. It is expected that, by resorting to procedures by which noise has been successfully brought down in the crystal diode art, less noisy transistors will be produced.

In the frequency variation of both N_e and N_c, it has been found approximately that the noise voltage squared per unit band width is inversely proportional to frequency. Figure 11 shows a typical noise versus frequency plot in which this relationship is demonstrated for N_e and N_c. The frequency dependence has been examined in detail from 20 cycles per second to 16 kc per second for some of the transistors investigated and determined by spot checks at 450 kc per second and one megacycle per second for occasional transistors.

In most transistors, correlation between N_c and N_e is found to exist, although of unpredictable magnitude. Within the assumed restrictions on phase already stated, negative correlations up to 80 per cent have been found.

FREQUENCY LIMITATIONS

The highest frequency at which a transistor can be used in a given application is a matter of interest to the engineer. The information at present available on this subject indicates that useful transistor performance is limited to frequencies below about ten megacycles.

Because of the comparative ease of its measurement as a ratio of two alternating currents, the current amplification factor α has been studied in some detail as a function of frequency. Figure 12 shows plots of α versus frequency for a type-*A* transistor at constant collector bias current and two different values of emitter bias current. The phase angle of α is plotted in the lower part of the figure for the same biasing conditions.

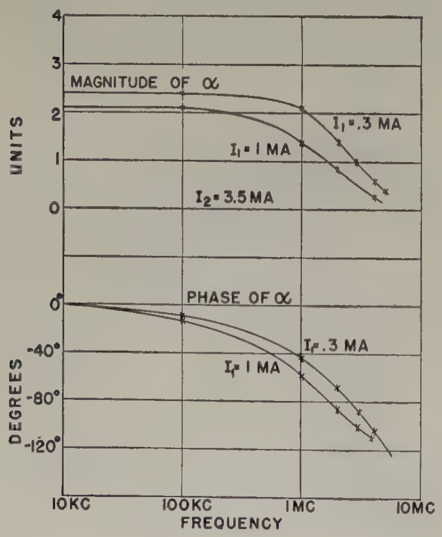

Figure 12. Current gain versus frequency plot for a type-A transistor

Approximate measurements, on a limited number of transistors, of the individual elements of the equivalent circuit show that r_e, r_c, and r_b are reasonably constant up to at least ten megacycles per second, that r_m alone changes with frequency, and that the changes in r_m are sufficient to account for the variations in α already presented. These findings are in accord with the existing knowledge that the forward and reverse resistances of germanium diodes are practically constant in the frequency range depicted. The variation of r_m with frequency can be attributed to a transit-time dispersion associated with the interaction between the emitter and collector currents.

Some tentative verification of this transit-time supposition has been obtained in a set of α versus frequency measurements on a series of double-surface units having different germanium thicknesses at the contact site. For units with thicker germanium the α curves fall off at lower frequencies, while the correspnding phase lags are greater at any given frequency in the dispersion region.

Double-surface transistors do not differ greatly from type-*A* units in the frequency dependence of α.

Table II. Equivalent Circuit Parameters and Their Temperature Coefficients

	I₁ and V₂ Are Kept Fixed for Each Unit											
Transistor	r_b 25 (Degrees Centigrade)	$\beta \times 10^4$ 0–25	$\beta \times 10^4$ 25–50	r_e 25 (Degrees Centigrade)	$\beta \times 10^4$ 0–25	$\beta \times 10^4$ 25–50	r_c 25 (Degrees Centigrade)	$\beta \times 10^4$ 0–25	$\beta \times 10^4$ 25–50	r_m 25 (Degrees Centigrade)	$\beta \times 10^4$ 0–25	$\beta \times 10^4$ 25–50
A1790	140	56	28	280	28	28	16,000	−240	−48	41,000	+60	−28
A1791	108	44	−28	220	28	−20	36,000	+100	−160	40,000	−112	−120
A2200	107	32	32	180	20	20	9,300	+12	−48	12,000	+64	+16
B89	210	16	−28	147	18	21	30,000	−40	−110	52,000	−40	−40
B90	500	0	0	315	−7	84	14,500	−160	+12	29,000	−80	−12

Table III. Insertion Gain in Decibels Versus Ambient Temperature

Transistor	I_1 and V_2 Fixed for Each Unit: 0 (Degrees Centigrade)	25	50	E_1, R_1, E_2, R_2 Fixed for Each Unit: 0 (Degrees Centigrade)	25	50
A1790	26.2	26.2	26.2	26.6	27.3	26.7
A1791	23.3	24.3	25.0	22.4	23.5	22.9
A2200	18.9	19.5	19.9	20.1	20.6	20.8
B89	26.2	26.5		26.0	26.8	27.2
B90	22.1	24.0	23.8	21.6	23.3	23.8

AMBIENT TEMPERATURE EFFECTS

In planning for the practical application of the transistor it is necessary to know the effect of the changes in ambient temperature which the device may experience in use. Experiments were performed to obtain such information.

The characteristics of three type-*A* and two double-surface transistors were measured successively at 25, 50, 25, 0, and 25 degrees centigrade. The performance characteristics chosen were the equivalent circuit parameters and the insertion gain. Since the d-c bias conditions change with ambient temperature it is necessary to decide which bias conditions are to be kept constant. For one set of tests, I_1 and V_2 were chosen for each unit at 25 degrees centigrade so as to maximize the gain and minimize the distortion. These bias conditions then were kept constant for succeeding ambient temperatures. The results are given in Table II and the left part of Table III. In Table II, the quantity β is the temperature coefficient for the corresponding resistance. Values of β are given for 0 to 25 degrees centigrade and for 25 to 50 degrees centigrade.

It is to be noted that the temperature coefficients are moderate and that they may be either positive or negative. The coefficients for r_b and r_e are smaller than those for r_c and r_m. The largest values occur in r_c and may amount to about one per cent per centigrade degree.

In another test the external electromotive forces and resistances were kept constant for each unit. R_1 was 500 ohms for all units. R_2 was 20,000 ohms for type-*A* and 10,000 ohms for double-surface units. For each unit, E_1 and E_2 were chosen to maximize the gain and minimize the distortion at 25 degrees centigrade and then were kept constant at succeeding temperatures. In this test only the gains were measured. The results are given in the right side of Table III. The gain changes are similar to those in the left side of Table III.

In most cases the gain increases with temperature. The increase may amount to one decibel in 25 degrees centigrade. Between 25 and 50 degrees centigrade the gain may decrease by a fraction of a decibel. These changes in gain are less than might be expected from the changes in equivalent circuit constants, probably due to the fact that changes in circuit constants tend to cancel each other.

In the course of these tests it was found that the values of the circuit constants determined at 25 degrees centigrade after a treatment at either 50 or 0 degrees centigrade differed from the original values by as much as a factor of two either up or down. Similarly the gain might permanently increase or decrease by about two decibels. Such changes are due to slight shifts in either the collector or emitter points resulting from stresses caused by the different expansion coefficients of the materials used.

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The Coaxial Transistor

WINSTON E. KOCK   R. L. WALLACE, JR.

The success of the earlier types of transistors led to the exploration of other forms of similar amplifiers, one of which is the coaxial transistor. A description of its construction, characteristics, and many advantages are contained in this article.

THE TRANSISTOR is a semiconductor amplifier using two point contacts pressing against a small block of germanium. It has been described by J. Bardeen and W. H. Brattain.[1] When the two point contacts are placed close together on the surface, and proper bias potentials are applied, there is a mutual influence between one contact, called the "emitter," and the other, called the "collector," which makes it possible to use the device to amplify electric signals.

Shortly after the discovery of the transistor, J. N. Shive of the Bell Telephone Laboratories observed that amplification also could be obtained with a germanium wedge when the emitter and collector points were placed on opposite sides of the wedge.[2] In this construction the germanium wedge is narrowed down to a sharp edge and the point contacts are placed on opposite sides at a point where the wedge is only a few thousandths of an inch thick.

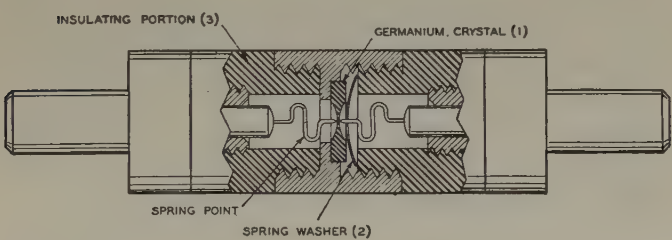

Figure 1. Cutaway view of first experimental coaxial transistor

The success of this unit led to the exploration of other forms of such amplifiers, one of which will be described here.

Investigation of the wedge device seemed to indicate that the current passing between emitter and collector actually was passing through the semiconductor and not around the wedge surface. Thus the effect was apparently not a surface phenomenon but rather a current amplification process occurring within the semiconductor itself. If this were true, transistor action also should be possible by reproducing the wedge geometry in circularly symmetrical form, thereby providing complete shielding between emitter and collector points. These considerations, when taken into account led to the development of the coaxial transistor.

CONSTRUCTION

A disk of germanium, one-eighth inch in diameter and 20 mils thick, was cut from a thin slab of germanium by means of a hole saw. Two dish-shaped depressions were ground and lapped into the faces of the disk by means of a spherical tool. The germanium wafer was placed in a mount shown in Figure 1 and held in place by spring pressure. In the cutaway view shown in Figure 1, (*1*) indicates the germanium disk, and (*2*) the spring washer, and the point contacts are seen to press against opposite sides of the disk. Most of the parts in this assembly are standard piece-parts used in the manufacture of single point rectifiers. For the experimental models, the insulating portions, (*3*) in Figure 1, were made of lucite for ease of fabrication. A photograph of this construction is shown in Figure 2 with the individual components spread out for observation.

The germanium disk, normally grounded electrically, is seen to provide an electrostatic shield between the emitter and collector points, and all three parts—emitter point, collector point, and germanium disk—are seen to be coaxial.

PROCESSING PROCEDURE

It was found experimentally that high polish of the active surfaces of the germanium allowed the passage of higher collector currents before burnout occurred. Therefore, the spherical surfaces were polished with a very fine grade of diamond lapping compound and followed with an electropolish operation. Where maximum current capacity is not required, the usual transistor treatment of etching and later electrically forming the collector point by passing

Full text of conference paper, "The Coaxial Transistor," recommended by the AIEE technical program committee for presentation at the AIEE winter general meeting, New York, N. Y., January 31–February 4, 1949.

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The authors wish to acknowledge the aid of their associates. They particularly are indebted to J. N. Shive and R. A. Ehrhardt.

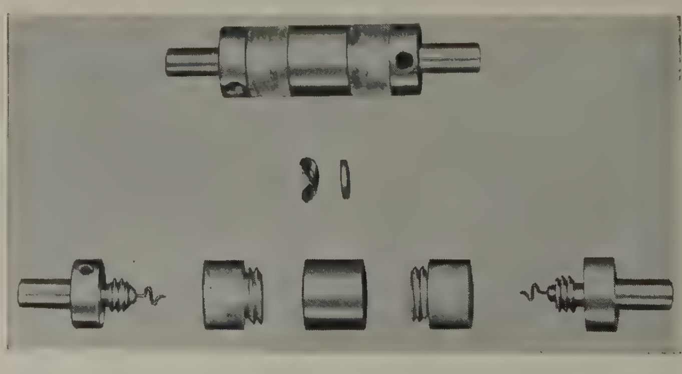

Figure 2. Exploded view of model in Figure 1

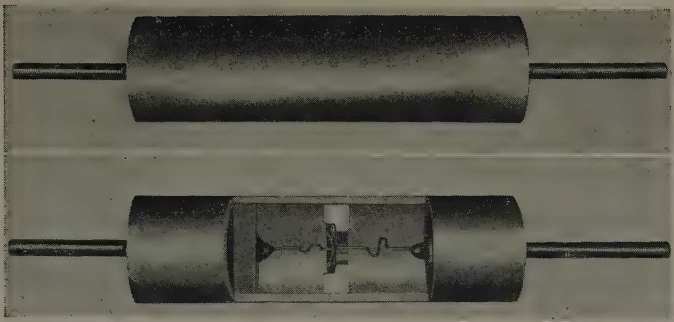

Figure 3. Cutaway view of proposed production model

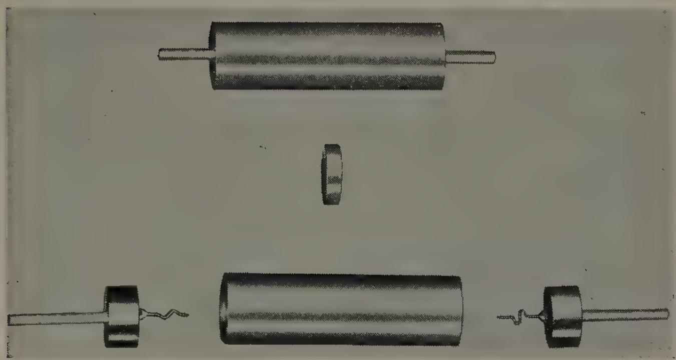

Figure 4. Exploded view of proposed production model

large currents in the reverse direction[1] also yields satisfactory results.

With the highly polished surfaces desirable for the higher current operation, it was found that points which were not perpendicular to the surface often had a sufficient tangential component of force to cause them to slip as they were pressed against the surface. In the coaxial construction described here, the two contact points are on opposite sides and thus can be exactly perpendicular to their contacting surfaces.

SMALL SCALE PRODUCTION MODEL

A construction which permitted moderate quantity production of these units is shown in Figures 3 and 4. Here a metal case was used to support the germanium wafer, and dielectric plugs carrying the emitter and collector points were forced into opposite ends of the cylindrical metal case until contact was made.

ELECTRICAL CHARACTERISTICS

The d-c characteristics of a typical sample of the coaxial transistor shown in Figures 3 and 4 are given in Figure 5. The characteristics compare moderately well with those of the semiconductor triode having both points on the same side of the germanium.

ADVANTAGES

The advantages which might be attributed to the coaxial construction are improved stability of the points, especially on highly polished surfaces; electrostatic shielding between input and output circuits; and the avoidance of construction problems involving the placing of two spring contacts within a few thousandths of an inch of one another. Constructional tolerances are not completely avoided by this design, however, since the two points should be accurately in line on opposite sides of the germanium for most satisfactory operation.

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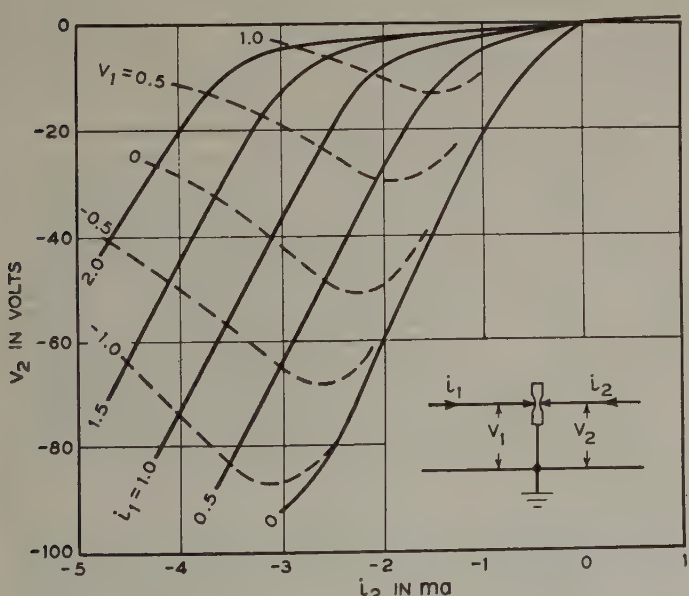

Figure 5. Static characteristics

Floating Powerhouse

Westinghouse Electric Corporation, East Pittsburgh, Pa., has announced the completion of a floating powerhouse designed to carry electric power into water-covered regions such as Lake Maricaibo, Venezuela, to help extract oil, The powerhouse will provide power for the world's largest marine-type Diesel-electric drilling rig, mounted on a barge 70 feet wide by 175 feet long. Three 400-kw d-c generators are utilized to make up the main power plant and supply all the electricity needed for drilling purposes. Four 75-kw auxiliary generators supply power for lighting and other auxiliary loads. The electric motors for the drilling rig have a combined rating of 2,600 horsepower. Included are three 500-horsepower motors for pumping the mud, lubricating the drilling bit, and carrying cuttings to the surface; one 800-horsepower hoist motor; and one 300-horsepower motor for rotating the bit. There is also one 60-horsepower motor for powering the mud-mixing pump.

Recent Research on Pulsed Light Sources

W. T. WHELAN

A SYSTEM has been developed which permits synchronous operation of stroboscopic light sources with certain commercial, optically compensated, and shuttered high-speed cameras. While the use of pulsed light sources for making high-speed motion pictures is not new, it is believed that this is the first successful synchronous system which combines the desirable features of one-microsecond flashlamp exposures with optical compensation of the blur caused by the continuously moving film in the high-speed camera. For this reason, the high-speed motion pictures which this system produces exceed in quality and definition those pictures taken previously. Up to 3,000 exposures per second can be made with presently available cameras.

Forced ionization of the flashlamp by means of a triggering surge is not used in this system because the 10- to 15-kv operating voltage of the system is more than sufficient to fire the lamps. Serious design difficulties were encountered when such voltages were first attempted.

Hydrogen thyratrons are used as the discharge switch which connects the flashlamp to the energy storage capacitor bank, and although the peak discharge current is of the order of one to two kiloamperes, satisfactory thyratron life is realized despite severe overloading. Investigation of the dynamic arc characteristics during discharge was necessary in order to plan appropriate switching and protective gear for the discharge circuits. New transient-recording oscillographic equipment made the study possible. Elaborate circuit precautions were necessary in order to maintain wave-form fidelity.

Figure 1. Flashlamps which have been used successfully with the modulator

Flexibility has been incorporated into the system whenever possible. A number of commercial flashlamps, Figure 1, can be used interchangeably without circuit alterations and successful multiple flash operation of spark-gap light sources of the type used in ballistic and aerodynamic research has been achieved. Ordinary polyethylene flexible coaxial cables are used to connect the flashlamps to the higher level modulator which permits ready placement of lamps for photographic purposes.

A packaged unit of six lamps, power supply, synchronizing and interlacing panels, and a pulse modulator unit for each lamp constitutes the basic system. Tandem operation of two or more systems is accomplished simply, and a maximum of two independent cameras per 6-lamp system is tolerable.

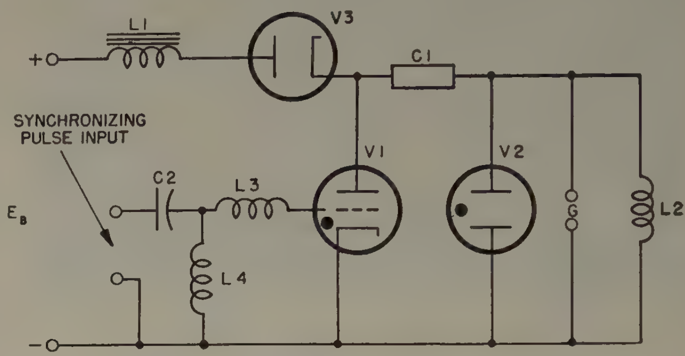

Figure 2. Typical pulse modulator circuit

V1 = Hydrogen thyratron, type 5C22
V2 = Flashlamp, types FT-121, FT-125, or FT-127
V3 = Clamping diode, pair of paralleled type 8020's
G = 20-kv protective gap
C1 = Energy storage network
C2 = Trigger grid coupling capacitor
L1 = 2-henry charging choke
L2 = 1-millihenry closing choke
L3 = 100-microhenry noise suppression choke
E_B = 6–8-kv power supply

The maximum demand per 6-lamp unit is of the order of 15 kva at 90 per cent power factor. A 6-phase electronic rectifier power supply is used and is designed to operate from a 208-volt 3-phase system. The d-c output voltage from the power supply is variable from 6 to 8 kv. A voltage doubling circuit is used to change the energy storage network. Low- and high-voltage overload protection is provided. Figure 2 represents the modulator circuit used. Its similarity to the high level radar modulator is obvious. It also has been used for multiple-spark operations where repetition rates of 2,000 cycles per second were obtained successfully, with no marked decrease in thyratron life even though large amounts of energy were dissipated.

Digest of paper 48-236, "Recent Research on Pulsed Light Sources," recommended by the AIEE instruments and measurements subcommittee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Scheduled for publication in the AIEE *TRANSACTIONS*, volume 67, 1948.

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Push Button Switching in Telegraph Systems

R. F. BLANCHARD W. B. BLANTON

"PUSH-BUTTON SWITCHING" is a continuation of the development of reperforator switching in the handling of telegrams through central telegraph offices. It is essentially a mechanization project in which the human element is largely replaced with mechanical and electric devices. The desired goal was faster and more accurate transmission of telegrams at lower operating costs. All of these goals were achieved in large measure with the successful development and application of reperforator switching.

In its barest essentials, reperforator switching consists of receiving line signals in printing telegraph 5-unit code on a printer-perforator which records those line signals on a paper tape; passing that tape through an intraoffice transmitter which may be connected through a switchboard or "turret" to a selected intraoffice path which terminates in a reperforator on the sending terminal of another circuit; the latter reperforator again records the signals in another paper tape which in turn flows through a line transmitter which sends them on to the proper destination. It replaces receiving operators, route clerks, route aides, and transmitting operators with clerks who simply read the destinations of telegrams as they are received, mark off the numbers on number sheets, and connect transmitters to intraoffice circuits at switching turrets. All route clerks and route aides are dispensed with and switching clerks can handle considerably more telegrams per day than receiving and transmitting operators formerly handled.

The printer-perforators used in this system, perforate holes in the paper tape corresponding to the printer 5-unit code for controlling the intraoffice transmitter signals, and also prints the characters on the same tape for facility in reading the messages by switching clerks. An intraoffice transmitter is mounted adjacent to each printer-perforator and tapes tend to flow continuously from the latter into the former. "Switching control" signals are perforated at the end of each telegram, however, which causes the intraoffice transmitter to stop and to be disconnected from the intraoffice path after the transmission of each telegram. This is an essential feature of reperforator switching because it is unlikely that two or more consecutive messages received from any circuit will be destined for retransmission over the same outgoing circuit. It is necessary, therefore, that the switching of all telegrams be on a "single-shot" basis, in order to control their distribution to the correct destination circuits. Automatically disconnecting the intraoffice transmitter from the intraoffice path, also releases that path instantaneously for use by other transmitters that may be waiting for it.

Intraoffice transmission is on a 5-wire basis with all five pulses of each character or letter transmitted simultaneously in order to secure high speed. A speed of 125 words per minute is used in intraoffice transmission as compared with line transmission and reception of 65 words per minute. This difference in speed offsets the time consumed in actually performing the switching function, and also the "holding" time which occurs when a desired intraoffice path is found to be busy. It also permits an assignment of switching clerks on a more productive basis since it is not essential that they set up the intraoffice connection instantly as a telegram is received. Each clerk may attend as many as three or more receiving positions and the high-speed intraoffice transmission compensates for elapsed time before she gets to a position to perform her function, and there will be no undue accumulation of unswitched telegrams. Accumulation that does occur is absorbed by the 125 word per minute intraoffice transmission.

In earlier installations, the connections from intraoffice transmitters to intraoffice reperforators were made with plug and jack types of switching turrets. In the push-button switching system, the switching turrets are composed of push buttons only, which control rotary switches that establish the connections. Greater over-all speed of transmission, greater accuracy, and higher switching clerk production resulted from this improvement. This type of central office operation has been so successful in field trials at Philadelphia, Pa., Cincinnati, Ohio, and elsewhere, that it has been standardized for use in most of the nation's major telegraph centers and forms an integral part of the country-wide mechanization program which the Western Union Company will complete in another year or two.

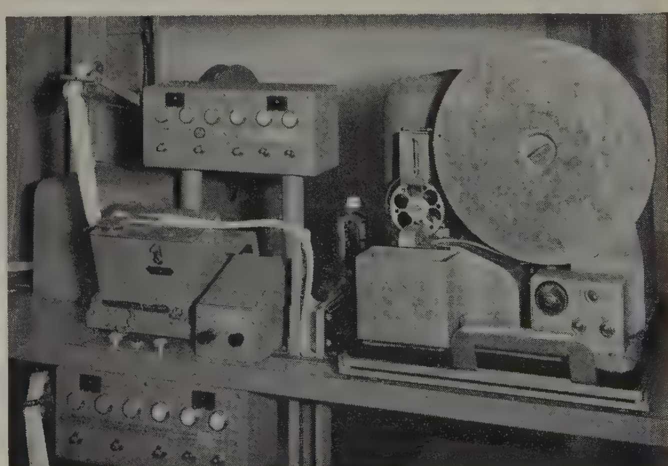

Figure 1. Receiving position with line printer-perforator of the 23-A chad-tape type, and intraoffice transmitter

Digest of paper 48-317, "Push Button Switching in Telegraph Systems," recommended by the AIEE communications committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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Performance of Dust-Contaminated Insulators in Fog

BRADLEY COZZENS
MEMBER AIEE

T. M. BLAKESLEE
MEMBER AIEE

CLIMATES having long dry periods allow considerable dust to accumulate on line insulators. The performance of these dust-contaminated insulators in fog-laden atmospheres constitutes a major problem.

A series of comprehensive tests was conducted at Ryan high-voltage laboratory of Stanford University. Energized strings of insulators of various designs were placed in the mouth of a wind tunnel where they were subjected to cycles of dust and fog applications. Synthetic dust comparable in chemical composition and in conductivity characteristics to dust accumulations found on insulators in service was admitted into the air stream of the wind tunnel to blow across the insulator strings at wind velocities of both 20 miles per hour and three miles per hour. Artificial fog was generated and allowed to drift by the insulators while leakage current was recorded and observations of insulator performance were noted. The data were correlated with observations of insulators on actual transmission circuits in the field to establish the validity of the testing procedure.

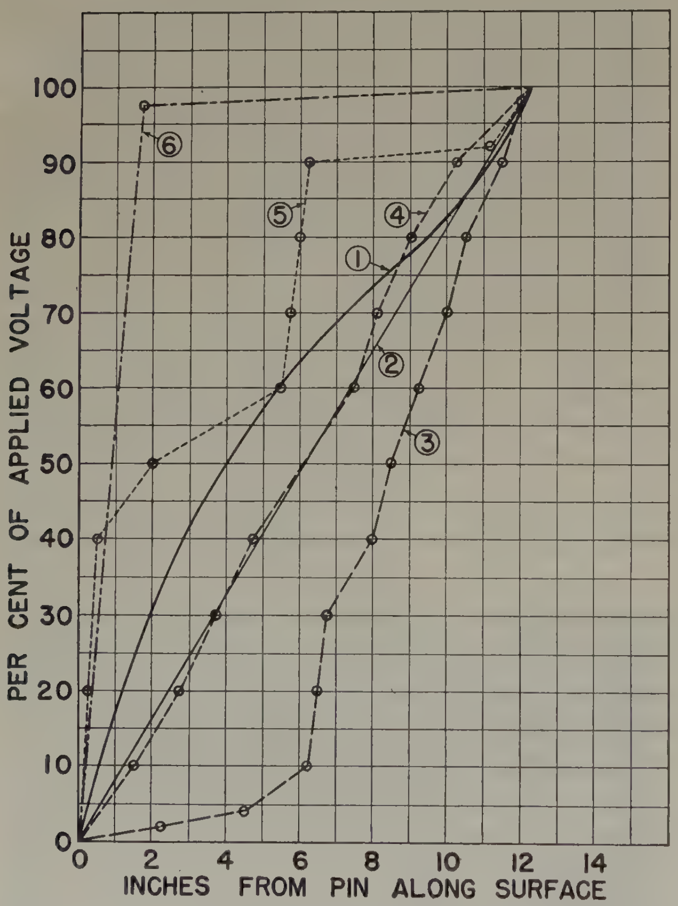

Figure 1. Voltage distribution over surface of suspension-type insulator unit

1. *Theoretical curve based on uniform resistance per square inch*
2. *Theoretical curve for resistance proportional to distance*
3. *Distribution on unit from line, 2,000 volts applied*
4. *Distribution on unit from test, 2,000 volts applied*
5. *Distribution on unit from line, 10,000 volts applied*
6. *Distribution on unit from test, 10,000 volts applied*

The tests and observations resulted in a good understanding of the performance of insulators under such conditions. The normal voltage distribution that exists over an insulator string as a result of electrostatic capacitances of the units is obscured by a distribution determined by leakage currents, 10 to 100 times the capacitance current, flowing through the surface resistances of the dust-covered insulators. Figure 1 shows the voltage distribution over the surface of suspension-type insulator units, comparing theoretical values with actual values of insulators which have been removed from transmission lines or have been subjected to the full test procedure. As a result of heat developed over sections of the insulator surface, certain areas of the insulators become dry, thereby increasing the resistance of such areas and forcing them to take large portions of the total voltage. The dry areas become overstressed and therefore exhibit corona, sparking, or flashover to give higher leakage currents.

It is concluded that insulator strings operating on transmission lines in fog will flashover when such leakage currents reach 50 to 60 milliamperes. The color of the sparking on insulators may be indicative of the performance, but is misleading sometimes because of coloring caused by elements in the deposited salts. A blue sparking on the units generally indicates that the insulator string is performing satisfactorily. When the arcs across dry areas adjacent to the insulator pins are deep yellowish or reddish, the current over the string is high.

A trouble-free insulator has not yet been developed and the problem currently is combatted by maintenance programs of periodic high-pressure water-stream washing. Washing equipment consists of a truck equipped with water tank, high-pressure pump, and fire-type extension ladder. The pump produces pressures between 500 and 800 pounds per square inch at the nozzle, and the ladder permits raising the man and nozzle to sufficient elevations properly to wash insulators on 34.5-, 115-, and 138-kv circuits. An insulator-washing program reduces leakage currents to the extent that freedom from flashover or disturbing noise is assured, provided the washing schedule is adjusted in accordance with the conditions encountered. Insulators are washed with safety on energized circuits operating at voltages as high as 287.5 kv.

Digest of paper **48-308**, "Performance of Dust-Contaminated Insulators in Fog," recommended by the AIEE transmission and distribution committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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Safety in Aircraft Electric Systems

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The novelty of the present high-voltage aeronautical electric systems requires designers to realize their responsibility for safety in design, and the aircraft personnel to be trained in safe working techniques. The author describes many hazards and how they can be avoided through proper design and job safety training.

THOSE RESPONSIBLE for industrial and public safety are well aware of the hazards existing in the low-voltage industrial electric systems, including the familiar 120-volt supply in residential use. The records of household and industrial accidents and fatalities from commercial 120-volt installations are generally well known.

The acceptance in aeronautical electrical design of the so-called higher voltage 120-volt d-c and 120/208 volt 3-phase a-c systems elevates this problem of electrical safety to one of immediate importance in contemporary design. A recent survey shows that in one large aircraft manufacturing organization, two electric shock accidents requiring medical attention already have occurred to manufacturing personnel presumably familiar with this new 3-phase a-c system and trained for the job. It is now the immediate responsibility of the aircraft electrical designer and the engineering department of which he is a member not only to design electrically safe installations but also to take the initiative in requiring proper job safety training to all aircraft manufacturing personnel and airline personnel who may be expected to be involved with the newer high-voltage aircraft electric systems.

There are two important sources of safety hazard for aircraft personnel. The first is the danger of electric shock and burns resulting from personal carelessness, or ignorance of the basic dangers of electric systems. The second is the shortcomings of engineering design which do not remove all recognizable personnel hazards incorporated in equipment components and installations on board aircraft.

ELECTRIC SHOCK

The conditions under which serious electric shock can be experienced must be known to be avoided. A 120-volt shock can be dangerous, and can and has been fatal. Seven determining factors are involved in electric shock which control the severity of the shock on the victim:[1]

1. Current pathway through the body.
2. Physical condition of the victim.
3. Magnitude of the current.
4. Shock duration.
5. Frequency.
6. Wave form.
7. The phase of the heart cycle at the instant the shock occurs.

To evaluate the comparative danger of the 120-volt d-c and 120/208-volt 3-phase 400-cycle a-c systems now employed on aircraft, the magnitude and the frequency of the shock current are definitely deciding elements.

The physiological reaction to 400-cycle current is very closely the same as to 60-cycle current.[2] With 3-phase a-c alternators rated as high as 37.5 kva and 120-volt d-c generators rated as high as 15 kw, effectively the same degree of shock hazard exists on such airplane circuits as exists in the equivalent residential or industrial power system.

The magnitude of shock current is determined by the applied voltage and the total impedance of the shock current circuit through the body. The internal resistance of the human body is[3] within the range of 700 to 1,000 ohms from one extremity to another. Surface contact resistance of the body may vary from 50,000 ohms or more down to effectively zero depending on whether the skin contact is wet, sweaty, and dirty. With 1,000 ohms as the total body resistance plus a contact resistance for the worst condition, 120 volts would produce 120 milliamperes of shock current.

Extensive testing of human and animal subjects[3,4] estimates that a conservative value of 9-milliamperes alternating current, at the frequencies considered herein, is the largest shock current that can be let go by healthy males using muscles directly affected by the shock current. A value of current much above this is considered dangerous. For d-c shock, the effect of muscular paralysis is much less, and a safe value of shock current of about 60 milliamperes is given. For a-c shock currents of about 100 milliamperes or more, and d-c shock currents of 500 milliamperes or more, the

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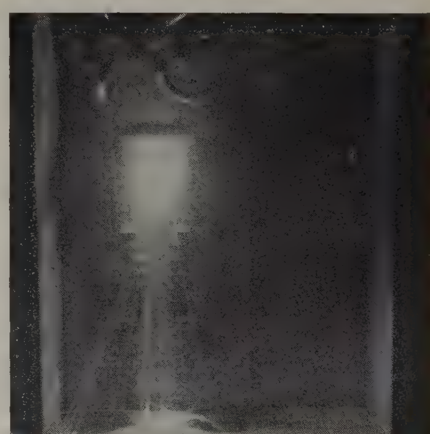

Figure 1. Rupture of low-voltage fuse on 120-volt d-c short circuit

The fuse is identical in size, shape, and mounting to fuse rated at 120-volts direct current made by same manufacturer

Figure 2. Rupture of circuit breaker on 120-volt d-c short circuit

The circuit breaker is used on both 28-volt and 120/208-volt a-c systems with satisfactory results

effect of the shock produces a heart condition known as ventricular fibrillation, wherein an aperiodic flutter of the heart muscles is substituted for the normal heart beat. This fibrillating condition is generally fatal because the brain and other organs can remain viable only a very few minutes, and this is not sufficient time for determination that this condition does exist. Moreover, no known practical method for treatment of ventricular fibrillation is available. Shock currents of several amperes produce general paralysis of heart, respiratory, or other muscles, and may cause severe internal deterioration of nerve, muscle, or other organs, as well as surface burns. Such shocks react to artificial respiration and other medical aids.

From the foregoing facts, it is deduced that the 120-volt electric systems used on aircraft provide sufficient power at sufficient voltage to cause fatal shock, and in particular, to cause death by ventricular fibrillation. Also it is seen that the 120/208-volt a-c system is at least five to seven times potentially more dangerous in this regard than is the 120-volt d-c system, because

1. The 3-phase system has available a much higher voltage, 208 volts line-to-line.
2. The let-go current for direct curreut is seven times larger than for alternating current.
3. The current for ventricular fibrillation is five times larger for direct current than for alternating current.

DANGER OF ARCS

Those aircraft personnel familiar with the commonplace 28-volt d-c systems, and not trained in electrical fundamentals, may fail to recognize that the use of high voltage nullifies their ability to judge the power carrying capacity of a circuit by the size of the wire. A number 10 wire can carry the same power at 120 volts as does a number 1/0 wire at 28 volts. The prevalent low-voltage practice of breaking circuits under load, of using clamp jumpers for temporary test circuits, and of cutting small wires carrying current, is one which can lead to severe personnel injury when applied to high-voltage systems.

There always exists the possibility that uninformed ground personnel will install on a high-voltage system a piece of equipment not intended for high-voltage operation. With respect to the familiar fuses, relays, switches, and circuit breakers used on the conventional 28-volt d-c system, explosion, arc, and fire of great severity generally result when such equipment is used on high voltage, particularly on 120-volt d-c circuits. Although many may realize that this is to be expected, it is not generally known how severe such explosion can be, nor how likely it is for this misuse of equipment to occur. This is particularly so where such equipment is used satisfactorily on high-voltage a-c circuits but not on high-voltage d-c circuits. As an example of this, Figures 1 and 2 show typical rupture of a low-voltage fuse and a low-voltage circuit breaker on 120-volt d-c short circuit. Note in particular the spray of molten fuse metal and glass in Figure 1. The danger from arcing is much greater on direct current than on alternating current.

DESIGN DANGERS

Where items of low-voltage and high-voltage equipment have their ground return wires connected to a common terminal and thence to ground, trouble will occur if this common terminal becomes disconnected from ground. This would allow the high voltage to feed through both pieces of equipment to the terminal of the low-voltage item where such high voltage would be totally unexpected. Closing the control switch to the low-voltage equipment would connect the high voltage to the entire low-voltage system. The high-voltage shock hazard would be limited in these conditions by the series impedances of both items of equipment, which easily may be low enough to allow dangerous shock currents to flow.

Metal switch gear and metal panels mounting high-voltage electric equipment require thorough and foolproof bonding to the frame of a metal aircraft. The use of the grounded metal frame is standard in metal aircraft. For safety, it is necessary that electric equipment developing internal short circuits or grounds be able to open the circuit protective devices and develop little voltage to ground.

CONCLUSIONS

This article is not to be construed as an argument against the use of high-voltage systems in aircraft. Technical considerations force the use of such voltages, and their use in airplanes is no more dangerous than in industry. The prevalence of industrial electrical accidents and the methods used to prevent them do not suggest doing away with 120-volt equipment.

Proper education of designers to their responsibility for safety of design is required. To this end, the design handbooks or other suitable reference manual used by engineering departments should include an appropriate explanation of electrical hazards and indicate the detail design standards recommended by that engineering department for the exclusion of such design shortcomings as already have been discussed. The design authorities must stress personnel safety continuously, in much the same manner as is now the practice regarding other safety measures as smoke evacuation and fire procedures.

The instruction of all aircraft service personnel in safe working techniques will help develop a proper respect for high voltage. The individual mechanic must be taught

the dangers which his ignorance or fool hardiness may produce, and the electrician certainly should be instructed in proper working habits to perform his job requirements in safety. In addition, descriptions of personnel electrical accidents should be published for their benefit.

It is a dangerous assumption to consider that the hazards described herein are self-evident and therefore require little mention or corrective action. In industrial practice, safety engineers constantly protect others from the "obvious" hazards which somehow go unseen by the accident's victim. During the training of Navy flight and ground crews for aircraft using 120-volt systems, the author found it necessary to use considerable time and repetition to impress on some personnel the importance of these problems to their own welfare.

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Power Supplies for Electrostatic Precipitation

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MEMBER AIEE

Industry has found a multitude of diverse applications for electrostatic precipitation. This article describes the functions of the various types of electrostatic precipitators in use today and points out their common characteristics, and in particular the similarities of their electric power requirements.

ONE OF THE most significant aspects of the present-day science of electrostatic precipitation is that it no longer can be considered a "one application" industry. For many years after Doctor F. G. Cottrell's development of commercially successful precipitators, the field was limited to the cleaning of industrial gases of various kinds. The advent of a precipitator for home, office, and factory air cleaning—in short, for cleaning air to be breathed—as developed by Doctor G. W. Penney, was an important milestone in the growth of an already successful industry. At present, we have, in addition to the two types mentioned, rapid growth in the branches of paint spraying and flock deposition. Thus it might be said that the utility of electrostatic precipitation is two-fold: first, as a highly successful, economically important tool of industry and, second, as an aid to better living through purification of atmospheres. The latter often produces economic as well as physiological benefits.

Heretofore, the various well-known applications of electrostatic precipitation principles have been considered independently. The time has come to recognize each such application as one phase of the precipitation industry. This industry has divided itself conveniently into four major branches, each of which is founded on a common basic principle, but which is distinct with regard to type of machine, kind of work done, electrical requirements, and economic advantages. It is the purpose of this article to examine these four fields of activity and to describe the electrical requirements of each.

SUMMARY OF THE INDUSTRY

The four principal subdivisions of the industry are illustrated in Figure 1. In each case, examples of applications are listed together with a schematic drawing of a representative precipitating machine.

Industrial Gases. Industrial gas precipitators are used in a wide variety of industrial processes to remove particles of matter from gases. An example of a unit installed in a small power plant is shown in Figure 2. These equipments often are called "treaters" or "Cottrells" in addition to the general term, precipitator. In a given application, the particle removing function may be useful for one or more of three reasons:

1. Nuisance abatement—example, removal of fly ash from the flue gases of power plants.
2. Recovery of valuable material—example, carbon black precipitation.
3. Providing clean gas for use—example, blast furnace gases.

Industrial gas precipitators are of two designs: the tube type shown in Figure 1(*a*) and the plate type. The selection of one type for a given application is based on the particular requirements present, the operating principle of each being essentially the same.

Full text of a conference paper, "Characteristics of Power Supplies for Electrostatic Precipitation," presented at the AIEE winter general meeting, New York, N. Y., January 31–February 4, 1949.

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Air Conditioning. This type of precipitator, Figure 1(*b*), was developed primarily for the purpose of cleaning the air which is to be breathed by humans. The term air conditioning is helpful in describing this class of precipitators although it refers, in this sense, only to the conditioning of air with respect to cleanliness rather than the usual inference of temperature or humidity control. The air-conditioning precipitator is well known for its applications in homes, offices, pharmaceutical plants, ball-bearing manufacturing plants, museums, and many others. Not so well known, perhaps, is its usefulness where unclean air may produce undue operating costs and inefficiency. An example of this case is in the use of these precipitators to remove oil mist from the air in the vicinity of machine tools. The result in such applications, in addition to eliminating a nuisance, is that excess cost for cleaning and impaired light intensity in the area is prevented.

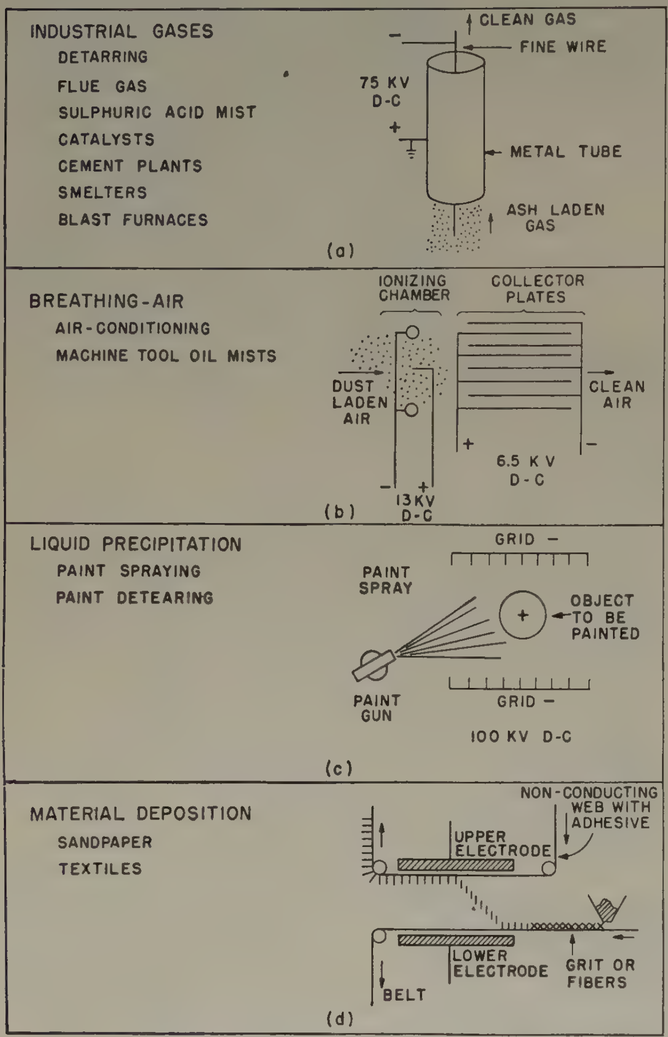

Figure 1. The four divisions of the electrostatic precipitation industry

Liquid Precipitation. Electrostatic paint spraying, as illustrated in Figure 1(*c*), has become a widely practiced method of lowering finish costs in the manufacture of high production items by reducing the amount of paint overspray and simplifying the finish operation. In addition, the quality of the finish often is improved by assuring an even deposit of paint on all surfaces of the part. The method is particularly adaptable to those parts having smooth contours, such as refrigerator cabinets; but often may be applied successfully in the painting of highly irregular surfaces. Electrostatic detearing is virtually the reverse of painting and is used primarily to improve the finish of dip-coated parts. The economics of electrostatic painting are marked, the savings often being sufficient to pay for the necessary equipment within a few months.

Deposition, Orientation, and Separation. This classification includes a variety of applications of electrostatic principles, which are described by the three terms; deposition, orientation, and separation. One illustration of material deposition is given in Figure 1(*d*). Examples of the three groups are:

1. Deposition—transfer of abrasive particles by electrostatic force to adhesive coated paper or cloth in the manufacture of sandpaper.
2. Orientation—alignment of textile fibers in the manufacture of pile fabrics such as rugs and artificial suede.
3. Separation—separation of minerals in ores, not readily sorted by other means.

ELECTRICAL REQUIREMENTS

The foremost electrical characteristic of precipitators is that they are essentially high-voltage low-current d-c devices. For example, although precipitators operating at potentials as low as 110 volts have been tested, the usual range is 10,000 to 100,000 volts. Current may vary from ten microamperes to five amperes. The co-ordinated electric equipment which supplies power to the precipitator may be called a power pack for convenience of nomenclature, although it may or may not be one integral unit.

Precipitators may be considered to have two separate modes of operation. In the first case, a steady state condition exists when a constant voltage is applied to the precipitator and the particles to be removed are precipitated at a constant rate. The ion flow in the precipitator, therefore the current measured, will remain constant. The second mode of operation is termed the transient condition and exists when a spark-over occurs between electrodes of opposite polarity.

Steady State. Although the electrical characteristics of the precipitator may vary slightly due to changing dust concentration and build-up of deposit on the electrodes, it is essentially an unvarying load. Therefore, nonregulating type of electric equipment with manual control of voltage and current is usually satisfactory. In those applications in which wide variation in equivalent resistance of the precipitator takes place, consideration should be given to regulators or other means of holding current or voltage constant as required by the load.

A second steady state consideration is that of current and voltage wave shapes and their effect on precipitator operation. Figure 3 shows typical current and voltage waves in a precipitator, particularly the industrial gas type, when

supplied electrically by a full-wave rectifier. The peak and average values of current and voltage are given. The peak voltage is of importance in that it is the determining factor in the frequency of sparking in the precipitator. The average voltage may be considered the quantity which determines corona discharge, therefore greatly influences efficiency of particle collection. The relationship between the peak and average voltage usually is expressed in terms of per-cent ripple; however, in precipitation work, it has been found convenient to express it as a ratio of peak to average voltage. In this manner, tests can be correlated when collection efficiency of a precipitator is investigated as a function of average voltage, peak voltage remaining constant. As an illustration of this point, tests on electrostatic paint spraying have shown that, for the same peak voltage, the wave shape having the higher average voltage produces the higher efficiency of paint deposition. However, other factors are present which may favor the use of low average-to-peak ratios, such as reducing the sparkover time by lowering the voltage at the end of each half-cycle. Thus it is necessary to examine the requirements of each type of precipitator and each particle class to determine the best steady-state power supply characteristics for the application at hand.

The peak-to-average ratio of current is important in

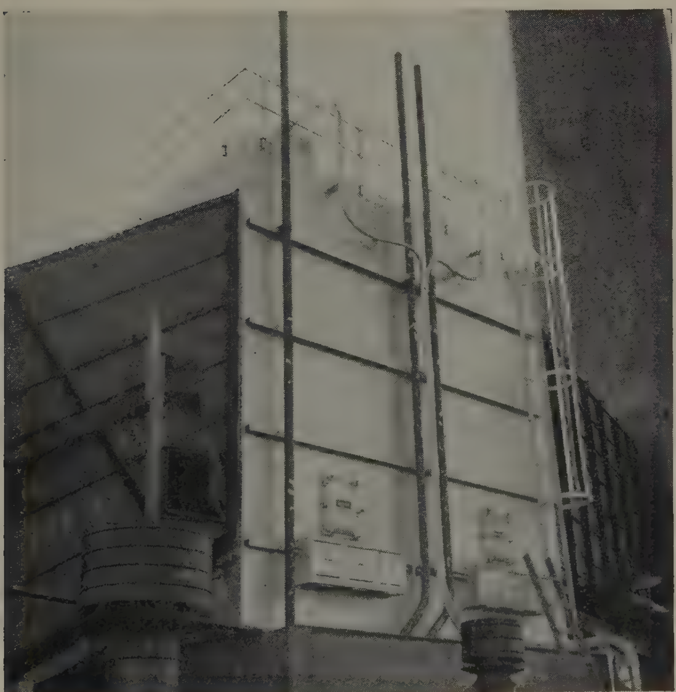

Figure 2. View of industrial gas precipitator for fly ash collection on the roof of a power plant

selecting a high-voltage rectifier for precipitation service. For example, the peak current in Figure 3 is twice the average value. In a full-wave rectifier, this is four times the average current per rectifier element, thus, if the peak current demand is 1.0 ampere, the rectifier element will operate at 250 milliamperes average or 500 milliamperes total for the rectifier. However, this may exceed the thermal rating of the rectifier, in which case the load cannot be carried by this rectifier. However, if the peak-to-average ratio of current is low, average current rating of the rectifier may exceed 500 milliamperes without exceeding the thermal rating of the rectifying element. Figure 4 shows typical volt-ampere characteristics of the ionizing section of one type of air-conditioning precipitator. Figure 5 shows the

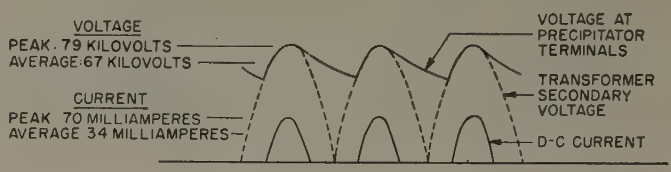

Figure 3. Typical wave shapes of voltage and current in precipitator

same characteristic for the collecting plates. These curves are typical of those for all classes of precipitators.

Transient Conditions. Generally speaking, precipitators operate most efficiently at that level of voltage just below the value which produces sparking. In some cases, notably in paint spraying, voltage is applied well below this level to avoid arc-overs which may produce hazardous results. When a spark does occur, transient surges of voltage and current will result. In all cases, it is necessary to limit the current surge either in duration or magnitude or both to protect the electric equipment adequately. In addition, the high-voltage transformer is usually well-shielded to protect the windings from stresses due to steep voltage wave fronts.

ELECTRIC EQUIPMENT

The electric equipment for precipitators consists of a high-voltage power pack and associated equipment such as high-voltage cable, and auxiliary control equipment such as rapper control and timers. In the case of air-conditioning precipitators, the power pack may be integral with the precipitator while in heavy duty industrial collectors, the power pack may consist of separate electric components.

Reviewing the fundamental requirements for high direct voltage, it is noted that three distinct classes of electric equipment may be considered for this purpose. These are

1. Electrostatic generator.
2. Radio-frequency power pack.
3. Conventional high-voltage transformer and rectifier operating at supply frequency.

Electrostatic generators have not been found suitable for precipitation service. Rating for rating they are generally larger, heavier, more expensive, and have undesirable electrical characteristics in comparison with the other high-voltage sources considered.

The radio-frequency power pack was developed to eliminate the supply frequency (for example: 60 cycle) iron-core transformer of the conventional high-voltage source. This may have a marked economic advantage for high-voltage

loads requiring very low current in the order of microamperes. In the radio-frequency power pack, an oscillator generates a high frequency, usually several hundred kilocycles, which then may be converted readily to a high voltage by means of a simple air-core transformer. The output is rectified by conventional means to obtain a direct voltage. The radio-frequency power pack, being inherently a low-

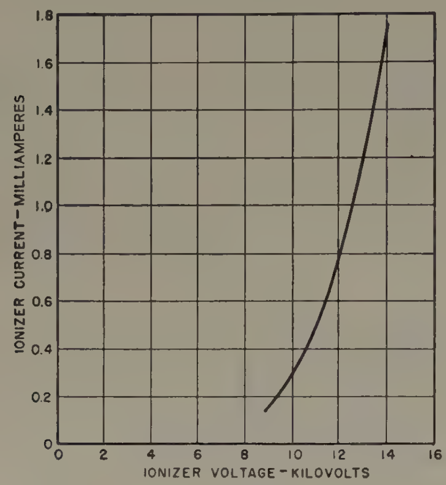

Figure 4. Volt-ampere characteristic curve of air-conditioning precipitator, ionizer section

power equipment, is best suited for such applications as air-conditioning and material-deposition precipitators.

Finally, the third class of high-voltage equipment, consisting of supply frequency transformer and rectifier, has a number of advantages over the first two methods and is used for all types of precipitators. The characteristics of this method are examined in detail in the following paragraphs.

Functions of the Precipitator Power Supply. In addition to transforming low-voltage power to high voltage, the three principal functions of the conventional power pack are

1. Rectification of high alternating voltage to obtain high direct voltage.
2. Adjustment of voltage to achieve optimum performance of the precipitator.
3. Limitation of current surges during the sparkover condition.

Methods of providing these functions in the power pack are listed in Figure 6.

With regard to rectification, an approximate distribution of present practice with respect to the three types shown is as follows:

	Electronic Per Cent	Mechanical Per Cent	Metallic
Industrial	25	75	0
Air conditioning	100	0	0
Paint spraying	100	0	0
Deposition, orientation, and separation	100	0	0

Electronic rectifiers using high-voltage kenotron tubes have become well-established as versatile, readily applied components for all four classes of precipitators. In service, records have shown in the few cases studied, average life expectancy in excess of 20,000 hours. The mechanical rectifier likewise has withstood the test of time and is particularly applicable for the relatively large power requirements of the industrial precipitator. The metallic rectifier has the advantage of being adaptable for totally enclosed unit design; however, it has not been widely used for precipitation service in the United States up to the present time. The inherent disadvantage of the metallic rectifier has been the low peak-inverse voltage rating of individual rectifier cells. For comparable voltage and current rating, this limitation leads to bulky, economically unfavorable equipments.

Several methods of accomplishing the second function of power packs, voltage adjustment, are shown in Figure 6. One of the simplest methods of obtaining variation of output voltage is by means of transformer taps (*a*) for broad voltage steps, and a series rheostat (*b*) for fine adjustment. The series rheostat has the dual-function of acting as a current-limiting device as noted. The induction regulator (*e*) is

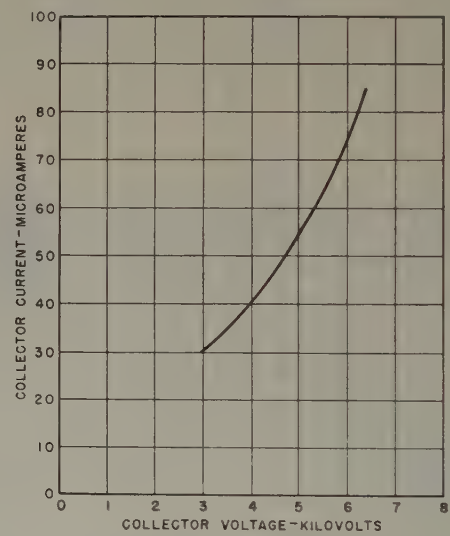

Figure 5. Volt-ampere characteristic curve of air-conditioning precipitator, collector section

also a convenient tool for control of output voltage. It has the advantage of providing stepless voltage adjustment with minimum consumption of power. An additional advantage is that it readily may be provided with a motor to permit remote control of voltage. The tapped reactor (*c*), saturable reactor (*d*), generator (*f*), and self-adjusting impedance (*g*) are alternative methods of controlling power pack output voltage.

The third function of power packs, namely, limitation of current surges when the precipitator sparks over, effectively protects the electric equipment during this condition of operation. Methods of providing this function are illustrated in the regulation or protection column of Figure 6. High-voltage transformers readily may be designed to have a relatively high value of leakage reactance (*h*) as a means of limiting surge currents. This method commonly is used in power packs for air-conditioning precipitators. In the case

of industrial precipitators, the two most common methods are the series rheostat (*j*) which limits the magnitude of the spark-over current and the electronic shutoff (*n*) which limits the duration of current. Other available methods are shown in this column and may be applied for this purpose depending on the particular requirements at hand.

Power Packs for Industrial Precipitators. Precipitators of this type operate at an average direct voltage of 40,000 to 60,000 volts and at a value of current which is a function of the volume of gas passing through the unit. Current is usually in the range, 50 milliamperes to two or three amperes. In the latter case, the precipitator is sectionalized and supplied by several power packs with the result that current per unit seldom exceeds 300 or 400 milliamperes. This practice has the advantage of keeping to a minimum the number of parallel precipitator sections, and in the case of electronic rectifiers permits operation of the kenotron tubes at maximum rating.

A typical electronic rectifier power pack for industrial precipitation is shown in Figure 7. The components from left to right are: (1) control panel which includes instruments, control switches, and control relays, (2) motor-operated induction voltage regulator, (3) high-voltage transformer and rectifier and (4) voltmeter multiplier resistor (with corona ring at the top). The characteristics of power packs of this type are such that when arcing occurs in the precipitator, a series resistor limits the value of surge current. If arcing becomes more frequent than predetermined rates, controls may be included to sound alarms, automatically reduce voltage, or remove power.

Power Packs For Air-Conditioning Precipitators. The voltage level of precipitators for home and office use is 10,000 to 15,000 volts direct current and has currents varying from 100 microamperes to several hundred milliamperes for very large installations. The rectifier circuit most commonly used to meet these requirements is the conventional full-wave voltage doubler. This circuit has the advantage of providing a half-voltage tap which often is used to supply power to the collector plates. The method of protecting the electric components in the event of precipitator arc-over is by means of high-leakage reactance in the high-voltage transformer. This method permits limiting maximum current to 200 to 300 per cent the full load rating of the power pack during short circuit. Voltage adjustment is provided by taps on the low-voltage winding of the transformer. Various control circuits include open-circuit and short-circuit indicating lights to show abnormal operation. A half-wave rectifier circuit is often suitable for precipitators of the simplest type, such as home units. An example of a 10,000-volt 0.4-milliampere power pack of this type is shown in Figure 8.

Power Packs for Paint Spraying. This application of electrostatic precipitation principles generally operates at a

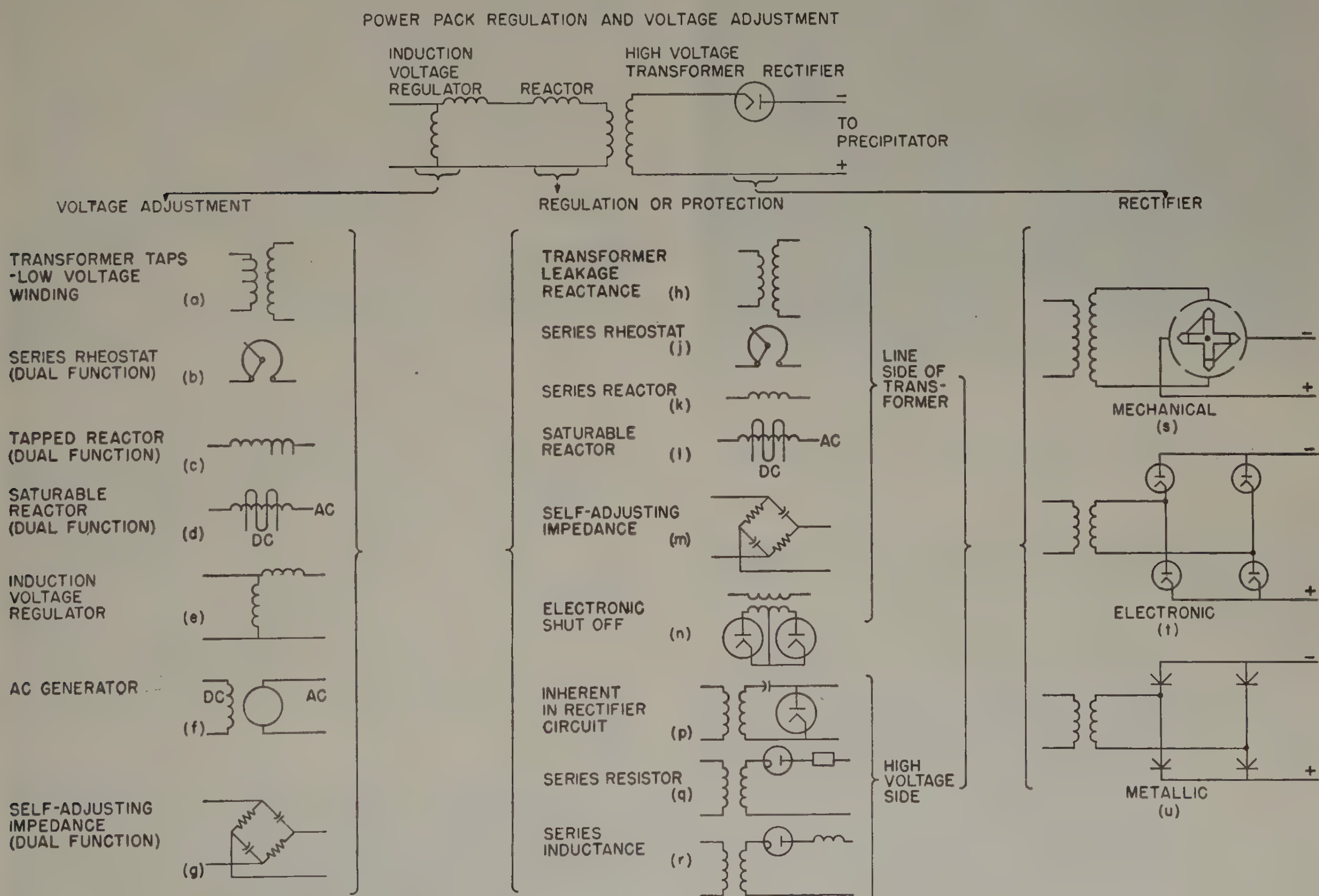

Figure 6. The basic circuit of a high-voltage power supply with methods for accomplishing each function

higher voltage and lower current than the two foregoing classes of precipitators. Voltage is in the range of 80,000 to 100,000 volts and the current seldom exceeds ten milliamperes. Various rectifier circuits may be used to meet this condition varying from the simple single-tube half-wave circuit to the cascading of voltage doublers. The latter method has the advantage of using lower voltage tubes than the half-wave rectifier and also provides a well filtered direct voltage which may result in increased efficiency of paint deposition over the half-wave rectifier.

Power Packs for Deposition, Orientation, and Separation. The electrical requirements of these processes are not unlike those for paint spraying with the exception that in this classification some processes operate best at high alternating voltages depending on the particular application. The electrostatic deposition of textile fibers in the manufacture of pile fabrics is particularly suitable for a-c power supply. In this case, a high-voltage transformer and control forms the necessary electric equipment. For such applications as sandpaper manufacture, direct voltages are preferred. In either case, voltage may be as high as 100,000 volts although satisfactory deposition may be obtained at the relatively low levels of 15,000 volts. Current requirements are less than ten milliamperes.

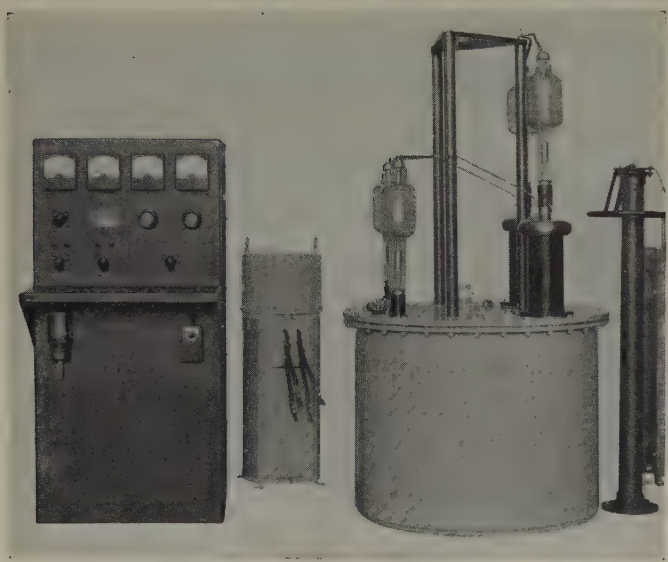

Figure 7. View of electrical components comprising a high-voltage power supply; rating 120,000 volts, 250 milliamperes

Method of Rating High-Voltage Rectifiers. The method of rating high-voltage power packs, and in particular, the voltage rating, often may lead to considerable error unless care is taken to specify where and in what terms the voltage is measured. In Figure 9, the voltage at *A-A* may be expressed in rms, or peak volts. The voltage at *B-B* may be expressed in rms, peak, or average volts accordingly as an electrostatic voltmeter, peak reading voltmeter, or D'arsonval type d-c voltmeter is used. Since the average and rms voltage at *B-B* are a function of load capacitance, these ratings will have little meaning as far as the power pack itself is concerned. This leaves rms and peak volts at *A-A* and peak volts at *B-B*. Two other factors affect the preferred voltage rating. With regard to instruments, the voltage may be measured most simply at *B-B* in average d-c volts or at the transformer primary in rms a-c volts. The second consideration is that voltage at both *A-A* and the transformer primary may deviate from a true sine wave, hence any single measurement of voltage does not produce a complete statement of the voltage condition. Thus, it may be seen that the voltage measured during operation or testing may differ from that used to rate the equipment. In the first case, either transformer primary rms volts or average d-c volts at *B-B* are preferred for observing normal operation. For purposes of rating, the transformer secondary rms volts are preferred. In the case of electronic rectifiers, the peak voltage at *B-B* is desirable when the regulation of the power pack is known.

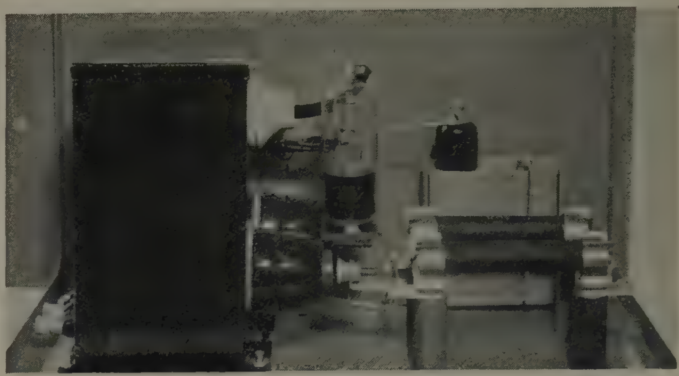

Figure 8. A 10,000-volt 0.4-milliampere power pack for air-conditioning precipitators of small capacity

The foregoing has described the functions of the various types of electrostatic precipitators in use today, and in particular their common characteristics. In like manner, the electric power requirements for the multitude of diverse applications have many points in common. The development of new high voltage techniques as the science of electrostatic precipitation advances, will result in mutual progress in many phases of the industry.

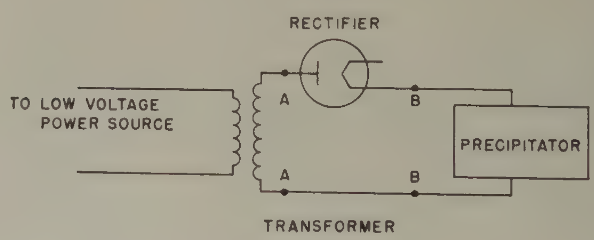

Figure 9. Rectifier circuit for illustration of method of rating in terms of rms, average, or peak voltage

Certain Characteristics of the Human Servo

F. L. TAYLOR

AUTOMOBILES, SHIPS, AIRPLANES, certain radars, and gun fire control systems are examples of complex devices built for human operation. As these machines are developed and improved they tend to become more automatic, with the man doing less to make them work. However, men will continue to play an important role in such activities for some years to come. So long as they do serve as controlling links in the electromechanical devices which they construct for their business, pleasure, or destruction, it will be necessary to understand how they operate as a part of these devices.

One of the most important roles of the human in a man-machine system is continuous control. The operator of a gun director watches the target through a telescope. When the target is seen to drift away from the telescope reticle the operator moves his tracking control. This, in turn, causes the power drives to move the director. Thus the operator may be considered as acting as one element in a complex servo control loop. When he is thought of in this way it is quite apparent that his characteristics are important in determining the characteristics of the complete system. In fact, it is evident that one must know the operator's transmission properties in order to design correctly the other elements in the loop. Values obtained for the man along with those for the other elements then could be substituted in an equation to predict the response of the over-all system.

However, there are certain apparent difficulties in the way of this treatment. At the present time, steady state and transient analysis techniques can be applied with profit only to fairly linear and relatively simple servos. Man is certainly not simple and in many instances it appears that he is not linear. It may be, therefore, that the techniques of servo analysis are inappropriate and inadequate for the determination of human transmission characteristics. A final answer to this question can be given if more is known about what the human operator does in the servo loop.

A good way to bring out the characteristics of man-in-machine behavior is to describe the results of experiments that have been performed at Naval Research Laboratory where the subject tracks a target with a joy stick. The target is a cathode-ray dot seen against a vertical hairline stretched over the face of the tube. As the target jumps to the right or left, the subject perceives the error and moves the joy stick to pull the spot back to the hairline. By means of appropriate measuring devices and differentiating circuits, his correction response is analyzed electrically into time plots of position, rate, acceleration, and rate of change of acceleration. These four plots appear simultaneously on the faces of four cathode-ray tubes.

The first thing to attract attention is that the subject's control is variable as he never makes two responses which are exactly alike. Sometimes he responds quickly, sometimes slowly; sometimes he overshoots in making his correction, at other times he undershoots. Person-to-person variability is also apparent. One subject may put in rates as much as double the rates of some other subject, or may have attained average accelerations four times as great as another.

The human also shows what has been called a "range effect" which makes for nonlinearity. It appears that when step errors of varying size are presented in random order, the subject's response to any given sized error is influenced by the relation of this error to the other sizes in the series. The small errors give rise to responses which are too high in rate and acceleration and the large errors induce responses which are too low. It is probable that the subject develops a "mental set" for responding to the average-size error and this influences all his responses in the direction of this average.

Likewise, actions along the following lines appear to occur which implies that man in his control functions is an intermittent system of a certain type. The subject perceives an error, organizes the response during the reaction time, and then triggers the movement. If the error changes markedly during the reaction time, or should the visually perceived rate of change of error during the response be out of harmony with what is expected, he immediately organizes a new response of appropriate size.

An even more disturbing characteristic is the human's ability to change with time. One of man's most prominent characteristics is his ability to learn, to acquire new responses to old situations. Learning has at least three effects upon follow-up behavior:

(*a*). It results in each human response being a function of the time in history of its elicitation.

(*b*). It permits the human operator to adjust to a wide variety of control arrangements.

(*c*). It makes it possible for man to anticipate the future.

Thus it seems that the human servo possesses characteristics which make mathematical analysis difficult. Considered as a control system, man appears to be highly variable, nonproportional, and intermittent. His ability to learn and to employ his intelligence introduces a host of dynamic nonlinearities not found in simple electro-mechanical systems. But this is not to state categorically that the methods of steady-state analysis or transient analysis are utterly inappropriate when applied to man. It is to say, rather, that they must not be employed blindly or in the routine fashion that one might deal with a mechanical servo. Future research may show that these techniques, when used properly with controls, checks, and subsidiary methods, will be useful in furnishing engineering data for the design of machines which man will operate.

Digest of paper 48-235, "Certain Characteristics of the Human Servo," recommended by the AIEE basic science committee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Not scheduled for publication in AIEE *TRANSACTIONS*.

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Instantaneous Bus-Differential Protection

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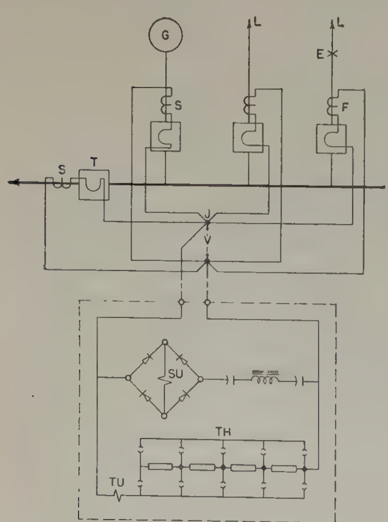
CURRENT TRANSFORMER core saturation has contributed largely to the difficulty of obtaining satisfactory bus differential relaying in the past. The scheme here proposed uses differentially connected standard bushing current transformers, and is supported by test data permitting wide application. The relay used has high impedance in comparison to the resistance of the current transformer secondaries and this accounts for its successful operation in precluding false tripping on external faults even when one or more of the current transformers has become completely saturated.

When maximum external fault current completely saturates the current transformer ("fault current transformer") through which it flows, and the current transformers ("source current transformers") on the other lines suffer no reduction in ratio, the sum of the secondary currents in the latter is forced through the secondary of the fault current transformer since no appreciable current can flow through the high impedance relay. The "error voltage" that thus appears across the junction points *J* (Figure 1) does not exceed the calculated drop through the resistance of the fault current transformer branch since the leakage reactance of this secondary circuit is negligible and its magnetizing impedance is cancelled out by the primary ampere-turns of the total external fault current which necessarily at least equal the secondary ampere-turns. To avoid false tripping on external faults, the relay is set to pick up at a voltage exceeding this maximum value of the error voltage.

Under internal-fault conditions, the voltage across the junction points approaches the open-circuit voltage of the current transformers and to limit the peaks of this voltage to a safe value, a Thyrite resistor is connected across the relay.



E—External fault
F—Fault current transformer
G—Generator
J—Junction point
L—Radial lines
S—Source current transformer
SU—Sensitive unit
T—Tie circuit breaker to another bus section
Th—Thyrite resistor and tap block
TU—Thyrite unit
V—Error voltage

Figure 1. Bus section with differentially connected type PVD relay supplied from bushing current transformers

For reasonable values of internal fault current the resulting voltage still exceeds the pickup value.

The relay, designated type *PVD*, includes two units: the sensitive unit, a plunger-type relay connected in a series reactor-capacitor resonant circuit that provides high, essentially resistive, impedance and blocks the d-c component of secondary current from the relay; and the Thyrite unit, operated by current through the tapped Thyrite resistor, that provides for high-speed tripping on high internal faults. Operation time for the sensitive unit is between three and six cycles; for the Thyrite unit, one to three cycles.

The first installation of this bus-differential scheme is at the Ripley generating station of the Kansas Gas and Electric Company on a 3-section 60-kv bus having a maximum of five circuit breakers per section. The maximum external fault current is 13,400 amperes rms symmetrical and the minimum internal fault current is 700 amperes. For these conditions the sensitive unit pickup is set at 265 volts, and the primary current required to pick up the relay on the section with five circuit breakers is 252 amperes. This setting therefore provides ample protection.

Factory tests were made with the most unfavorable conditions imposed, including d-c premagnetization of current transformer cores, fully offset primary current waves, time constants ranging from 0.05 to 0.15 second. Current ranged to 160 amperes secondary with a relatively high secondary lead resistance. Analysis of the test oscillograms supported the theory and formed a basis of determining settings of the two relay units for a wide range of applications.

Calculations based on assumed values of lead resistance have been made for all bushing current transformers used in the circuit breakers listed by one manufacturer, and the resulting application data are available.

It is found that the ratio (maximum external fault current to relay pickup current) for the five common examples varies from 75 to 130; the lowest ratio among all 55 ratings now in production is 14. In conclusion it is pertinent to summarize certain outstanding advantages of the bus-differential system:

1. Standard relaying type bushing current transformers are used, for which only the open-circuit excitation data and secondary winding resistance need be known.

2. The system gives high-speed protection for moderate and severe faults.

3. Performance for specific applications is subject to simple calculation, which will show a large margin in many cases.

4. Protection is easily extended if the number of connections to the bus is increased.

Digest of paper 48-311, "Instantaneous Bus-Differential Protection Using Bushing Current Transformers," recommended by the AIEE relay and transformer committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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Brightness and Contrast in Television

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More consideration is given to the quality of the television picture at this time as the television industry moves along through its expansion period. In this article the author describes the role that highlight brightness and contrast range play in producing the picture quality that is most pleasing to the eye.

HOW BRIGHT does a television picture need to be? The American Standards Association's recommendation for motion picture screen brightness is ten foot-lamberts without film in the gate. With clear film this value would drop to approximately eight foot-lamberts. The highlight brightness of the average 16-millimeter home color movie is approximately one-half this value, or four foot-lamberts as measured on a screen three feet wide. Thus, if television were to be viewed only in darkened rooms, these brightness values, based on motion picture experience, would be adequate.

There is, however, an important factor which in most instances prevents both motion picture and television images from being satisfactorily viewed in a well-lighted room—the loss of contrast range. Since motion picture and television screens freely reflect the surrounding light, a lower limit is set automatically to the darkest shades reproducible.

A good picture, whether film, television, painting, or engraving, should appear to the eye to have a contrast range of approximately 30:1. This means that the highlights of such pictures, when viewed with surrounding illumination, should be about 30 times brighter than the darkest shade obtainable under such conditions.

Paintings, drawings, and photographs usually display deep satsifactory shades of blacks since the dyes, paints, or printing inks employed for black are extremely light absorbent, thus insuring adequate contrast range. Usually, it is taken for granted, therefore, that regardless of the amount of light directed onto a photograph or painting, the contrast range remains the same.

However, motion pictures and television, two media which derive their blacks from an absence of light, cannot present shades darker than those determined by the surrounding light. Thus, to approximate the contrast range of the original scene, the highlights of these images, as a rule, would have to be many times brighter than the ambient room illumination. Motion picture projectors, whether in the theater or at home, are unable to furnish this extra brightness and, therefore, the pictures must be viewed in the dark. Television pictures, whether black-and-white or in color, unquestionably will be viewed during times when darkening the room would be inconvenient. Let us examine what happens to television images under such conditions.

The light reflected from the walls of the average artificially lighted room is seldom in excess of five foot-lamberts. Allowing for reflection loss, this also represents the maximum highlight brightness of the pictures and photographs on the walls of such a room. During the day, with natural illumination, the brightness values are higher. It is safe to assume that television rarely would be viewed in rooms where the illumination of the area surrounding the receiver is more than 20 foot-lamberts.

The majority of the current black-and-white direct-viewing television receivers, when located in rooms where the ambient illumination is 20 foot-lamberts, reflect approximately 15 foot-lamberts from their screens. To obtain a contrast range of 30:1 in pictures produced by these receivers, the necessary highlight brightness would have to be 15 × 30, or 450 foot-lamberts.

Actually, many receivers do not furnish more than 30 foot-lamberts measured on a blank raster. Thus, with an ambient illumination of 20 foot-lamberts, the maximum contrast range will not be in excess of 3:1 (the ratio of the maximum highlight brightness of 30 plus 15 foot-lamberts to the reflected ambient room light of 15 foot-lamberts). If one wished to obtain a contrast range of 30:1 with these receivers, the reflected illumination from the screens would

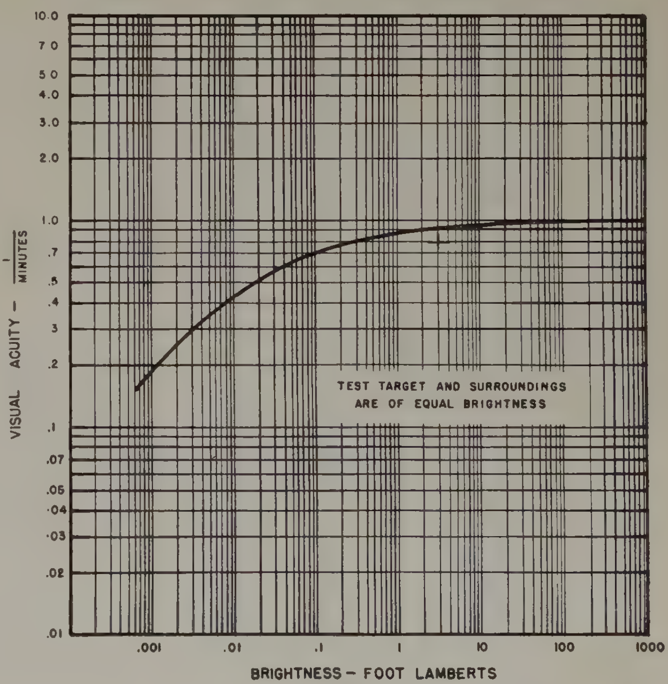

Figure 1. Visual acuity versus brightness

Full text of conference paper, "Brightness and Contrast in Television," recommended by the AIEE technical program committee for presentation at the AIEE winter general meeting, New York, N. Y., January 31–February 4, 1949.

Peter C. Goldmark is the director of the engineering research and development department, Columbia Broadcasting System, Inc., New York, N. Y.

have to be not more than 1/30 of the maximum highlight brightness, or one foot-lambert. Correspondingly, the surrounding illumination could be only 25 per cent higher, or 1.25 foot-lamberts—a dark room, indeed.

The conclusion one draws from this is that many present-day black-and-white receivers should not be viewed in rooms where the surrounding illumination is much in excess of one foot-lambert; otherwise, the picture will suffer from inadequate contrast range. Let us suppose that one wished to view television pictures with an ambient illumination as high as 20 foot-lamberts and the blank screen of the receiver were still to reflect 75 per cent of the ambient illumination, or 15 foot-lamberts. To produce the desired maximum contrast range of 30:1, the highlight brightness of the television images would have to be increased to a total of 450 foot-lamberts.

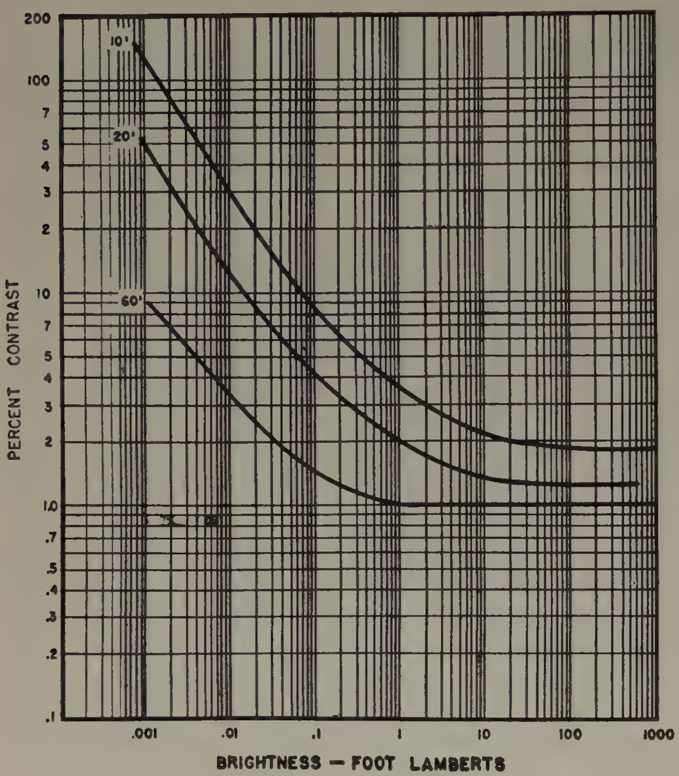

Figure 2. Contrast discrimination versus brightness

It is quite conceivable that commercial direct-view type receivers some day will be capable of furnishing a highlight brightness of 450 foot-lamberts. It is doubtful, however, that this would be a satisfactory solution, since viewing such a bright image without a correspondingly bright surrounding would be uncomfortable. Assuming that the presently used field repetition rate of 60 per second employed, such a picture would, in addition, display objectionable flicker.

Thus, it is evident from the examples cited that for adequate image recognition, contrast range is more important than mere brilliance. This leads us into certain considerations regarding the human eye.

One of the most important capacities of the eye is its ability to discriminate brightness in space. This often is called contrast recognition. It is measured as the relative brilliance of nearby areas with an incremental difference in brightness.

Under the best conditions, the human eye can discriminate between adjacent areas only when the contrast difference is not less than one per cent. This should not be confused with the ability of the eye to adapt itself to different light levels without appreciably impairing visual acuity. During a single day, our eyes may be exposed to a range of illumination of the order of one billion to one—from bright sunlight to dim starlight. For our purposes, we need only consider illumination levels which are in excess of approximately one-tenth foot-lambert.

It commonly is known that the capacity for visual acuity will vary with brightness. Other factors, such as contrast discrimination, flicker recognition, and color discrimination, also grow with brightness.

Figure 1 illustrates how visual acuity varies with brightness. On the ordinate, visual acuity is plotted in terms of the reciprocal of the visual angle (measured in minutes). Thus, the visual acuity of 1.0 represents the capacity of the eye just barely to resolve detail which occupies one minute of the visual angle. In the same way, for the eye to distinguish a certain detail which corresponds to a visual angle of ten minutes, a visual acuity of only 0.1 would be required, and so on. A visual acuity of 1.0 corresponds to a resolving power of 20/20. The maximum visual acuity which the human eye normally achieves is a little over 2.0.

The test object used to determine Figure 1 consisted of a grating composed of black and white bars. It is evident from this diagram that for brightnesses up to about one-tenth of one foot-lambert, the visual acuity increases fairly rapidly. Between two and 1,000 foot-lamberts, however, the visual acuity rises only a negligible amount—from 0.9 to 1.0. Thus, from the point of view of resolution, it hardly pays to increase the brightness of pictures above two foot-lamberts highlight brightness. It is important to note that the measurements represented in Figure 1 were made with a surrounding of the same brightness as the test target. Were the brightness of the surrounding much different from that of the target, the visual acuity not only would cease increasing, but actually would decrease, even if the brightness of the test object should be raised above five foot-lamberts.

The same holds true for the faculty of contrast discrimination. Figure 2 indicates the smallest contrast the eye can see at different brightnesses as applied to three different sized test areas. Even for such a small area as corresponds to a diameter of ten minutes, brightness pays off well only up to about two foot-lamberts, just as in the case of acuity. Beyond that, contrast recognition increases at a very slow rate with increasing brightness.

Contrast values for the three test target areas indicate that for a given brightness, the necessary contrast for barely perceiving a detail varies approximately as the inverse of that detail's size; in other words, the larger the object, the smaller need be the required contrast, and vice versa. Increased brightness is of use to the eye only if it brings with it

increased contrast. It is this increased contrast which assists the eye to see fine detail. Thus, if one wishes to see greater detail in a picture or a scene, one may increase the contrast, if possible, or else move closer to the scene or picture for a more detailed examination. The limit is set by the maximum possible picture brightness and then by the resolving power of the eye.

Several inherent properties of television make it difficult either to increase the brightness or view the picture from a closer range. The most basic limitation is that television pictures are made up of approximately 500 horizontal scanning lines. Each line can show no detail along its height, but can show variations along its length. No matter how closely one looks at a television screen, or how bright it is, no detail smaller than a square area, whose height is roughly that of a line, can be perceived.

Applying a visual acuity of approximately one, a television picture with 500 active scanning lines would have to be viewed at a distance of about seven times the picture height, in order that the available detail be resolved. Viewing it closer would not yield additional detail to the normal eye. At a greater viewing distance, however, the apparent resolution would decrease. Figure 3 shows this relationship between visual acuity and optimum viewing distance.

We can use Figure 1 to determine the optimum brightness with which it is possible to resolve a 525-line television picture. As pointed out before, a visual acuity of approximately 20/20, or nearly 1.0, corresponding to a visual angle of one minute, represents the resolving power of a normal eye, and, according to Figure 1, is achieved at a brightness of approximately one foot-lambert. This, however, represents unusually favorable conditions since the test target in Figure 1 had a high contrast range (black and white bars). In television, both fine and coarse detail often occur when the contrast is less than would correspond to the full range between black and maximum white. Therefore, one has to consider the influence of the picture illumination level on the resolving power of the eye for finer gradations.

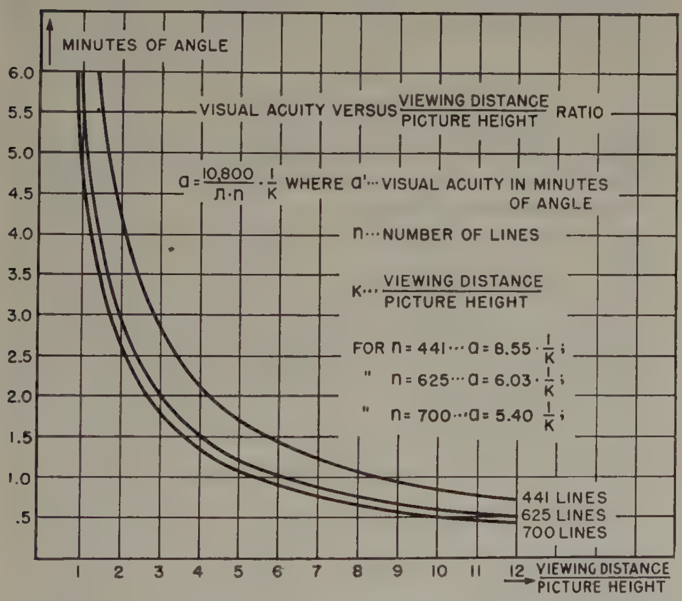

Figure 3. Visual acuity versus optimum viewing distance

It was shown earlier that a certain reciprocity existed in the relationship represented in Figure 2; namely, that for a given brightness, the minimum contrast discrimination and the test object size are, in the first approximation, interchangeable. Applying this to the specific television problem under discussion, we find that for a test object corresponding to a visual angle of roughly one minute, a picture highlight illumination of ten foot-lamberts would allow a minimum recognizable contrast step of about 20 per cent.

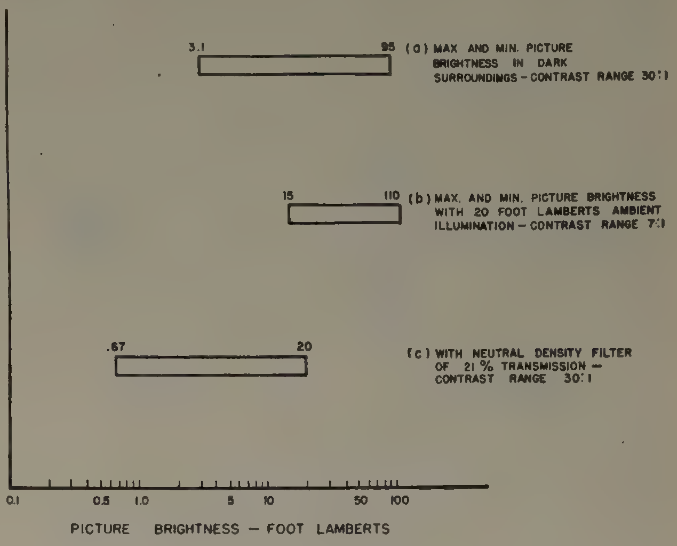

Figure 4. Effect of neutral density filter on contrast range (direct view tube)

Television pictures which contain a maximum contrast range of 30:1 are considered entirely adequate, although the present state of the art does not yet permit such a range to be maintained in fine detail. Accordingly, the 20 per cent minimum contrast discrimination for the finest picture detail in a 525-line system with a highlight brightness of ten foot-lamberts corresponds to a maximum of log 30/log 1.2 or roughly 19 discernible shades between black and maximum white.

It is thus evident that ten foot-lamberts highlight brightness is adequate from the point of view of resolution and contrast discrimination. It was this value which was quoted earlier as recommended for motion picture screen illumination by the American Standards Association.

One of the proposed solutions for producing adequate contrast range in television pictures suggested increasing the picture highlight brightness to a value many times above that of the surrounding brightness. This solution does not solve the problem because local illumination, which is much higher than the general ambient illumination, produces a sensation of glare, and glare reduces visual effectiveness. Experiments with visual acuity and contrast recognition have shown that both reach their optimum for a given brightness when the surrounding illumination is about the same as the locally illuminated area. A surrounding too bright or too dim tends to decrease effectiveness of visual functions.

When we gaze through a window at an outdoor scene, the window through which we look will be a source of glare to us. Not only will it produce discomfort, but our visual functions actually will be impaired, and our eyesight will be less perfect than if we viewed the scene surrounded by the same over-all brightness. This fact has become so important

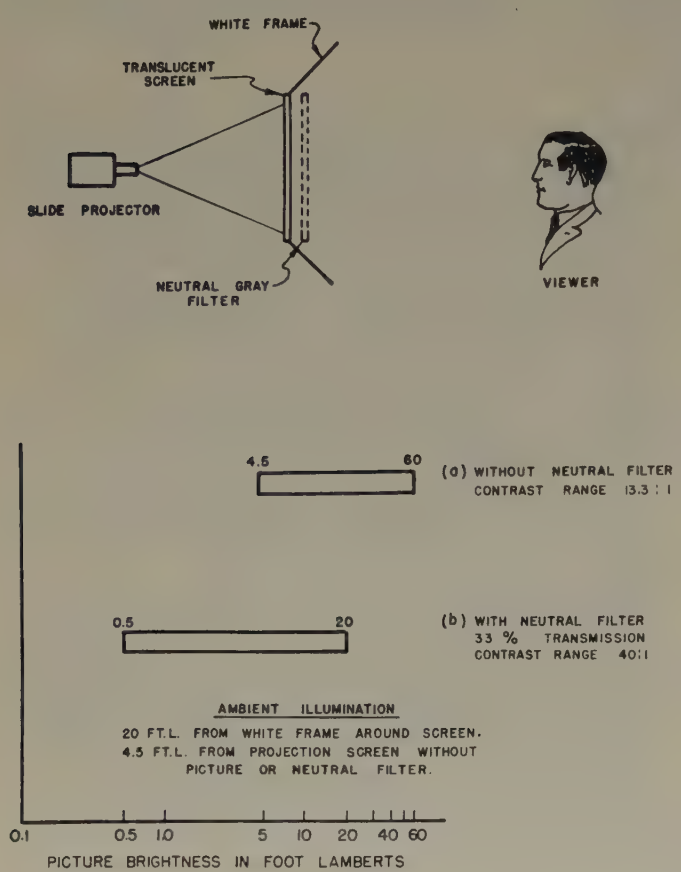

Figure 5. Contrast range of projected pictures in the presence of ambient illumination when viewed with and without neutral filters

in visual studies that it is an accepted practice to provide a large surrounding area of the same brightness as the test area under observation.

Quite aside from these considerations, it is not economical to produce television receivers capable of extreme picture brightnesses. Yet a way must be found to maintain adequate contrast range with normal ambient illumination.

A simple solution, which does not entail undue cost and yet is effective, is illustrated in Figure 4. Column *a* shows a picture tube illumination of 95 foot-lamberts plotted against a minimum brightness of 3.1 foot-lamberts. Viewed in a darkened room, the resulting maximum contrast range would be 95 divided by 3.1, or about 30.

Different conditions arise when the same picture is viewed in a well-lighted room with an ambient illumination of 20 foot-lamberts (as read on a white surface surrounding the picture tube). These are illustrated in column *b*, Figure 4. The maximum highlight brightness is now 110 foot-lamberts, which is the sum of the reflected ambient light, or about 15 foot-lamberts plus the original maximum picture highlight brightness of 95 foot-lamberts. Because the minimum possible picture brightness is 15 foot-lamberts, it follows that the resulting maximum contrast range is 95 divided by 15, or about 7:1. This would produce a picture of rather poor quality.

Column *c* illustrates what happens if a neutral density filter of 21 per cent light transmission were to be placed against the front of the cathode-ray tube. This filter could be a thin layer of gray cellophane, or any other suitable light absorbing material. The original highlight brightness of 95 foot-lamberts now is reduced to $\frac{95\times 21}{100}$, or 20 foot-lamberts. On the other hand, the reflected ambient light of 15 foot-lamberts is reduced by the square of the filter attenuation factor, resulting in a minimum possible picture brightness of 15 divided by 22.6, or 0.67 foot-lambert. The peak highlight brightness was 20 foot-lamberts, and thus, the maximum contrast range for this condition is $\frac{20}{0.67}$, or 30. It is important to keep in mind that this is possible with an ambient illumination of 20 foot-lamberts and a picture tube highlight brightness of only 95 foot-lamberts.

The following is a mathematical analysis of the effect of the neutral density filter on contrast and brightness. If the contrast range is limited by ambient illumination, then

$$I_A >> B_{\min}$$

where I_A is the surrounding light reflected from the picture screen, and $B_{\min}$ is the least possible brightness (corresponding to black) when the television receiver is viewed in complete darkness ($I_A = \theta$). Under the same conditions, $B_{\max}$ shall be the maximum picture highlight brightness. The contrast range then will be no greater than

$$\frac{B_{\max}}{B_{\min}} \tag{1}$$

When the ambient light I_A is not zero, the picture highlight brightness becomes $B_{\max} + I_A$ and the minimum brightness I_A; the contrast range will be

$$\frac{B_{\max}+I_A}{I_A} \tag{2}$$

When a neutral density filter with transmission factor a (where $0<a<1$) is placed in front of the picture screen so that ambient light can penetrate to the screen only through the neutral density filter, then the picture highlight brightness will be reduced to

$$(B_{\max}+I_A\times a)a$$

and the minimum brilliance to

$$I_A\times a^2$$

The contrast range then will be

$$\frac{a(B_{\max}+I_A\times a)}{I_A\times a^2}=\frac{B_{\max}+I_A\times a}{I_A\times a} \tag{3}$$

The increase in contrast range due to the use of the neutral density filter is 3 divided by 2, or

$$\frac{(B_{\max}+I_A\times a)I_A}{I_A\times a(B_{\max}+I_A)}=\frac{B_{\max}+I_A\times a}{a(B_{\max}+I_A)} \tag{4}$$

In the first approximation, $(B_{max}+I_A \times a)$ equals $(B_{max}+I_A)$ so that the increase in contrast becomes roughly $1/a$. If for instance, a neutral density filter is used with $a = 0.33$ (33 per cent transmission), and the ambient illumination were such that without the filter the contrast range were 10:1, then, through the use of the filter, the contrast range would increase three-fold or to about 30:1.

It was naturally desirable to find out what effect this trading of higher brightness and low-contrast range against lower brightness and high-contrast range would have on a group of observers. Actual tests were carried out in the Columbia Broadcasting System's laboratories late in 1946. The method used is illustrated in Figure 5.

A simulated setup was utilized, representing a television projection set capable of high initial brightness. A neutral density filter of 33 per cent transmission was placed in front of the projection receiver so that the surrounding illumination, incident on the screen, had to pass through the neutral density filter twice before reaching the observer's eye, while the picture brightness was reduced only once. The slide projector produced a 15 by 20 inch picture on a ground-glass screen. Around the screen was a large white border, and both were externally illuminated by the same source. The light reflected from the border measured 20 foot-lamberts, and the light reflected from the projection screen was 4.5 foot-lamberts. Without the neutral density filter, the picture had a highlight brightness of 60 foot-lamberts, and thus, with a minimum screen brightness of 4.5 foot-lamberts, the contrast range was about 13:1 (Figure 5, column *a*). With the neutral density filter in front of the projection screen, the highlight brightness was reduced to about 20 foot-lamberts, whereas the minimum screen brightness was reduced to one-tenth of its original value, or roughly one-half foot-lambert. As a result, the contrast range was trebled and became 40:1 (Figure 5, column *b*).

For the test, a number of different color slides were projected onto the screen from the rear. The picture highlight brightness, in each instance, was adjusted to measure 60 foot-lamberts without the neutral density filter. Seven observers participated in the tests, and each observer viewed seven different slides. Out of a total of 49 observations, in 43 instances the observers indicated preference for the picture with the neutral density filter (conditions as indicated in Figure 5, column *b*). In the other six observations, the individuals specified no preference. In no instance was there preference indicated when pictures were shown with greater brightness but less contrast (Figure 5, column *a*).

During these tests, the observers found, almost without exception, that a certain 3-dimensional effect, originally present in some of the color slides, disappeared when they viewed the projection pictures without the neutral density filter. They found, however, that it was present again when the contrast range was re-established, even though the highlight brightness was reduced to one-third of its original value.

The brightness of most objects of daily interest to us does not exceed the brightness of the surroundings. Museums are the best proof of this fact. Measurements were made in the latest and best equipped of these, the Museum of Modern Art, in New York City. The paintings and the surrounding walls were found to be diffusely illuminated from the same light source. Most of the walls were white, and the reflected light averaged six foot-lamberts. The whites of the paintings reflected about four foot-lamberts. The over-all effect was highly satisfactory, and all pictures could be viewed with complete comfort. This, again, proves that contrast at moderate brightness is far more important to the eye than brightness applied indiscriminately.

In the color television system developed by CBS, the direct-viewing receivers employ rotating color disks in front of the cathode-ray tube. The color disks necessarily absorb an appreciable amount of light from the visible spectrum, and the average light loss of the red, blue, and green filters is between eight and ten. This means that if the cathode-ray tube behind the filters had a highlight brightness of 200 foot-lamberts, the observer would see between 20 and 25 foot-lamberts.

This apparent loss of light, however, is compensated for to a large degree by greatly improved contrast range in the presence of ambient illumination. This again is due to the fact that the surrounding light has to pass through the color filters before being reflected back by the white screen of the cathode-ray tube, and then has to pass through the color filters again before reaching the observer's eye. As a result,

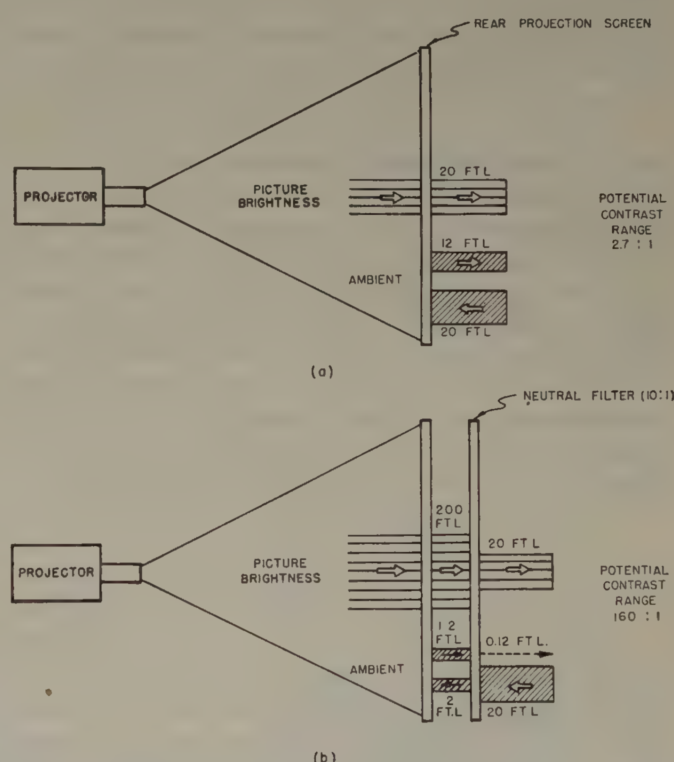

Figure 6. Effect of neutral gray filter in preserving contrast

color television receivers with color disks can be viewed in well-lighted rooms without loss of contrast range.

This process, taking place within the color television receiver, has been re-created in two projectors placed side by side, and the results have been photographed (Figures 6 and 7). Figure 6*a* shows diagrammatically how a picture

Figure 7. Photographs showing effect of light absorbing filters in preserving contrast

(Top) Projected pictures without ambient illumination. The left one has a neutral gray filter of ten per cent transmission in front of the projection screen. Both pictures have 20 foot-lamberts highlight brightness. (Below) Projected pictures with ambient illumination of 20 foot-lamberts as measured at the white square between the pictures. Conditions otherwise the same as above

screen, with a highlight brightness of 20 foot-lamberts and ambient illumination of 20 foot-lamberts, suffers from poor contrast range (2.7:1). To simulate the conditions created by the color filters, Figure 6*b* shows a resultant highlight brightness of 20 foot-lamberts, but with a potential contrast range of 160:1.

At the top of Figure 7, two identical slides are shown which were photographed in the dark; that is, without ambient illumination. The two pictures have the same highlight brightness, but are obtained in different ways. The picture on the left measures 200 foot-lamberts on the projection screen and is reduced to 20 foot-lamberts after passing through the neutral density filter. The picture on the right has no filter and measures 20 foot-lamberts. Thus, the camera shows the two pictures with the same highlight brightness and the same contrast range.

For the two lower slides of Figure 7, the surrounding illumination was 20 foot-lamberts; but the picture on the left, which still measures 20 foot-lamberts highlight brightness, shows the same quality as the one taken in the dark. The picture on the right, which is not protected by the neutral density filter or, in the case of the color receiver, by the color filter, has lost most of its contrast range, though it displays approximately the same highlight brightness as the picture on the left.

From the aforesaid, it is evident that in the presence of surrounding illumination improved picture rendition can be provided in direct-viewing type of black-and-white receivers through the use of neutral density filters. This process of improving rendition through the reduction of picture brightness appears to be paradoxical and, for that reason, frequently is misinterpreted. Our work in this field has been worthwhile if, as a result, a thorough understanding is achieved of the principles involved.

Measuring Heavy Direct Currents

A static direct-current transformer, like perpetual motion, has long been a sought-after impossibility. A new device used by Westinghouse engineers called a "Transductor" comes close, achieving the same objective for one special purpose. It provides a simpler, safer way of measuring extremely heavy direct currents.

In electrolytic plants, where currents of many thousands of amperes flow in a single bus, the traditional method of metering is to use a shunt (which may be almost as big as an office desk) in the bus and measure its voltage drop. Often this means long leads and placing the full bus voltage to ground on the meter. Both are sources of trouble and an actual hazard.

With the "Transductor" the massive shunt is replaced by a special current transformer of the through type. The secondary winding is energized by alternating current of some convenient low potential such as 110 volts. A change in direct current affects the reluctance of the "Transductor" magnetic circuit and in turn the current flowing in its a-c circuit.

This alternating current is measured on a conventional ammeter calibrated in terms of the direct current in the heavy current bus. Curiously a change in a-c energizing voltage affects the meter indication only slightly. The scheme, under practical plant conditions, is accurate to one-half per cent.

A 24,000-Rpm Alternator for Aircraft

T. J. MARTIN
MEMBER AIEE

DESIGNED TO BE DRIVEN at 24,000 rpm by a gas turbine, the *G-80* alternator is a 50-kw generator for supplying a-c power to 3-phase 208/120-volt 400-cycle aircraft electric systems. This equipment combines the lightness of high-speed electric rotating equipment with the possibility of direct connection to a high-speed gas turbine, thereby eliminating gearing and replacing the noise and vibration of the reciprocating engine with the comparatively quiet and smooth flow of power from the turbine.

The gas turbine, which is still in a very elementary stage of development, has a weight which is only about one-half to three-quarters that of a reciprocating engine of the same power. Its fuel economy at present is definitely inferior to that of the standard reciprocating engine, but it is believed that a few years of development will produce gas turbines with fuel economies comparable to, or better than, those of the reciprocating engine. Equipment used with turbines can be lighter, as much of the material required for strength to withstand the terrific vibration of the reciprocating engine can be eliminated.

The gas turbine is, by its nature, a high-speed device and is ideal for driving a 2-pole 400-cycle alternator, the synchronous speed of which is 24,000 rpm.

Operation of large power equipment at such high speeds introduces many problems which are absent or are of much less importance at lower speeds. The development of the *G-80* alternator and of the *TR-125* turbine has been a series of problems, most of them mechanical.

The rotor is supported by two ball bearings at the slip-ring end, operated back-to-back to establish axial alignment, and a roller bearing at the drive end. The design called for slight preload on the ball bearings, but experience showed that slight initial radial looseness was required to compensate for expansion with heat in operation.

The end turns of the 2-pole cylindrical rotor place a load on the end bands that tends to distort the bands into an elliptical shape. Therefore, it was necessary to design these bands as beams to provide adequate stiffness.

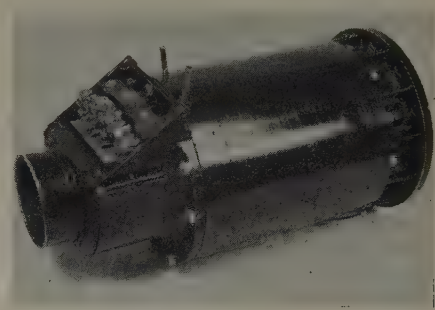

Figure 2. G-80 alternator, 208/120 volts, 6.25 kva, 24,000 rpm

Bearing lubrication was accomplished with an oil mist supplied by an atomizer.

Friction-type oil seals would not stand the high speed and were abandoned in favor of a simple labyrinth design.

The concentricity of the slip rings is very critical for this high-speed operation. Calculations showed that the brushes could stand a total slip-ring run out from all causes of 0.001 inch, but this is reduced by such factors as stiffness of brush shunts, friction in the holders, inertia of brush springs, and so forth. The design goal for the slip rings themselves was 0.0003-inch total run out, to which must be added the effects of radial looseness in the bearings, bearing concentricity, deflection of the shaft, if any, and vibration.

Digest of paper **48-243**, "A 24,000-Rpm Alternator for Aircraft," recommended by the AIEE air transportation committee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Not scheduled for publication in AIEE *TRANSACTIONS*.

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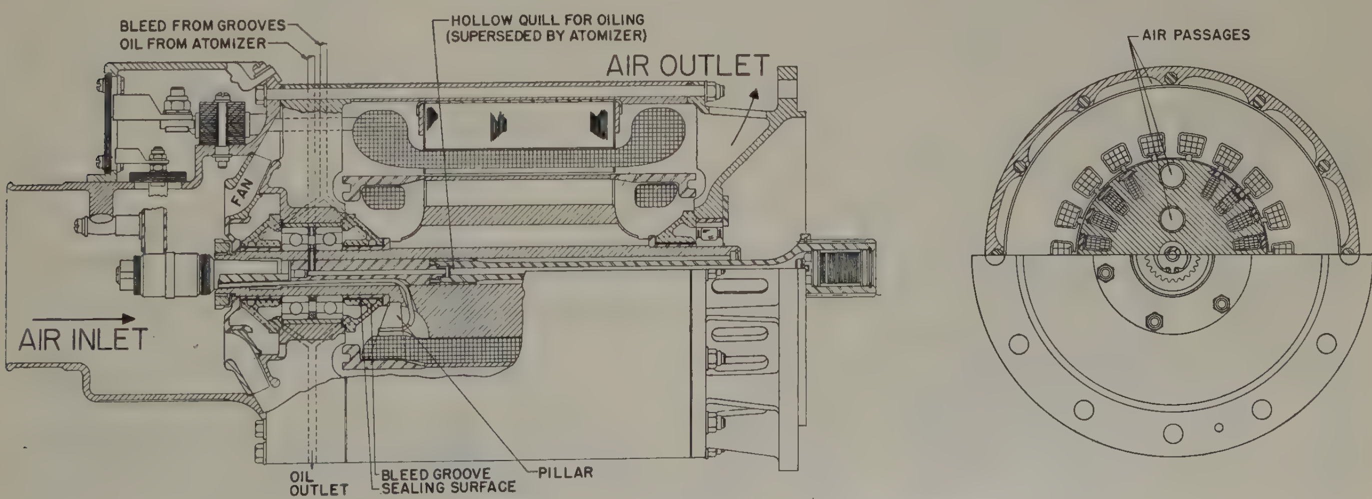

Figure 1. G-80 alternator assembly

Three-Phase Bus Proximity Effect Factors

T. J. HIGGINS
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H. P. MESSINGER
ASSOCIATE AIEE

THE THEORY underlying design of 3-phase coaxial busses comprised of square tubular conductors has been developed by the authors in a recent paper. In this article:

1. It is determined that the proximity effect factors of a given bus of coaxial square tubular conductors are essentially equal to the corresponding factors of a "similar" bus comprised of circular tubular conductors, each of which has external diameter and thickness respectively equal to the external side and thickness of the corresponding square conductor.

2. It is pointed out that in consequence of this equality the proximity effect factors can be calculated through use of Dwight's curves for the ratios R_{ac}/R_{dc} of the conductors of a 3-phase coaxial bus comprised of circular conductors.

This calculation is to be effected as follows. Corresponding to a given bus comprised of square conductors, effect the "similar" bus of circular conductors. From well-known theory, a circular tubular conductor carrying a current, of which the density can vary radially but not angularly over the cross section, produces no flux within the tube. Accordingly, the metal of inner conductor of a coaxial bus comprised of circular tubular conductors lies in a field produced only by the conductor itself. Thus the proximity effect factor K_p of the inner conductor is 1; whence the ratio $R_{ac}/R_{dc}=K_sK_p$ of the inner conductor is equal to the skin effect factor K_s.

In turn, as skin effect factor depends only on self geometry, the appropriate curve for the inner conductor also yields the skin effect factor of the intermediate conductor. Then if the value of R_{ac}/R_{dc} for the intermediate conductor is divided by this skin effect factor, the proximity effect factor of the intermediate conductor is obtained. Obviously, the proximity effect factor of the outer conductor is to be obtained in the same fashion. But, inasmuch as the proximity effect factors of the given bus and of the corresponding "similar" bus are the same, it follows that the desired proximity effect factors of the given bus have been obtained.

In illustration of this calculation consider the following example: to calculate the proximity effect factor for an intermediate square conductor having standard dimensions of edge $c=10$ inches and thickness $t=(c-d)/2=0.5$ inch. The skin effect factor for the "similar" circular conductor of ratio $t/D=0.5/10=0.05$ is $K_s=1.25$ (taken from the 0.05 curve for inner tube); the ratio R_{ac}/R_{dc} is 1.285 (taken from the 0.05 curve for outer tube). Hence, the proximity effect factor is $K_p=1.285/1.25=1.028$.

To reduce calculation and improve accuracy, the curves of Figure 1 have been plotted from points with co-ordinates calculated as in the example. From these curves can be obtained by inspection the proximity effect factors of the intermediate and outer conductors (that of the inner conductor is 1) of a 3-phase coaxial bus comprised of square tubular conductors. Illustratively, the 0.05 curve for outer conductor yields the value $K_s=1.03$ for the conductor of the example.

To determine the co-ordinates of Figure 1, a photograph of the original cut of Dwight's curve was enlarged about three times. From this enlargment, and aided by the fact that the curves were plotted on a grid of fine mesh, the co-ordinates of points on the curves could be obtained with considerable accuracy. It was from these values that the co-ordinates of the curves were calculated which are shown in Figure 1.

Digest of paper **48-276**, "Proximity Effect Factor for 3-Phase Coaxial Busses Comprised of Square Tubular Conductors," recommended by the AIEE basic sciences committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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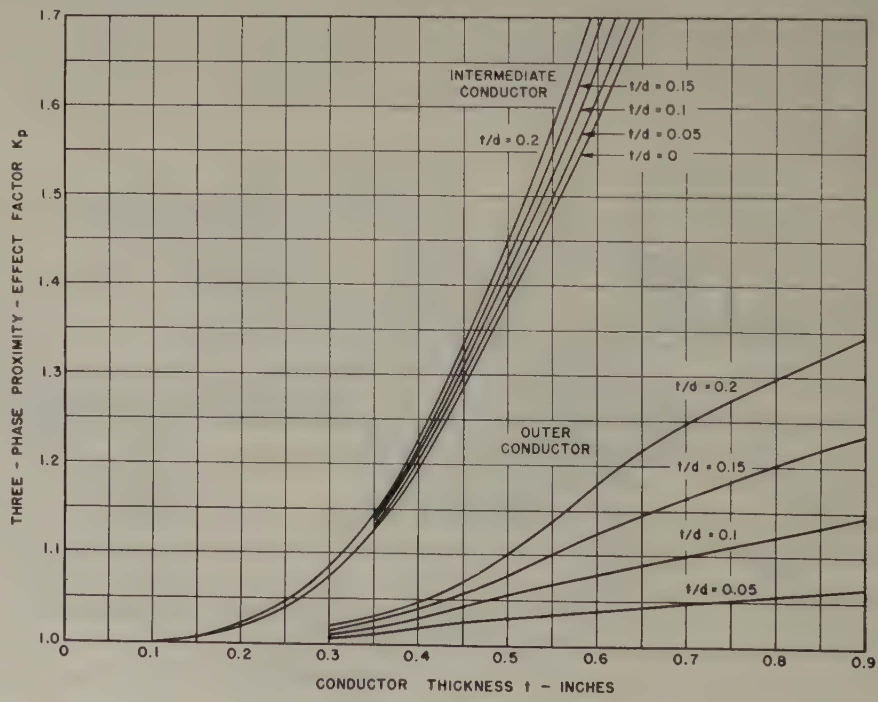

Figure 1. Curves of proximity effect factor for square tubular conductors

The curves obtained are for 60-cycle balanced currents with relative phase angles: Θ equals 0, 120, and 240 degrees, respectively. However, essentially the same values are associated with opposite phase sequence; again, values of K_s and K_p corresponding to any other frequency are obtained by multiplying the actual conductor thickness by $(f/60)^{1/2}$ and then using the curves as in the foregoing

Spark-Gap in Wonderland

"ALICE walked over to a workbench in the laboratory upon which there was some apparatus with an open laboratory notebook beside it. The apparatus consisted of a glass tube whose internal diameter was about four centimeters, containing two rather snugly fitting plane electrodes, clearing the walls by about a millimeter, and separated from each other by two or three centimeters. Wires came up to the tube, and there was a confusion of switches, meters, and gauges. Alice read in the notebook:

With one megohm in series to limit the current I applied 3,000 volts direct current to the spark-gap. No breakdown occurred. On lowering the voltage to about 2,000 volts, the gap suddenly broke down, glowing, with a current of 0.2 milliampere flowing through it. On raising the voltage, the gap is suddenly cleared, giving zero current. This I repeated many times. The gap spacing was 2.7 centimeters and the gas pressure was 0.8 millimeter of mercury.

"Said Humpty-Dumpty who had accompanied her into the laboratory:

'When I want to break down a spark-gap, I always lower the voltage impressed on it, and when I want to clear the gap, I raise the voltage impressed on it.' "

Is it only in Wonderland that spark-gaps such as described exist?

Answer to Previous Essay

The following is the author's answer to his previously published essay, "Electromagnetic Space-Ship" (*EE, Feb '49, pp 145–6*).

The author steps out of his role of inventor and into the role of critic in answering the questions raised in the essay.

The inventor of the electromagnetic space-ship is right in principle in calculating the unbalanced forces on his space-ship except that he does not go far enough. He rightly expects that corresponding to each element of volume dV of his empty space where he has an electric displacement current density, $\frac{1}{4\pi}\frac{\partial \boldsymbol{E}}{\partial t}$ and a magnetic field intensity $\boldsymbol{H}$, there will be an element of unbalanced force $d\boldsymbol{F}_1$ for his material system, given by $d\boldsymbol{F}_1=\left[\boldsymbol{H}\times\frac{1}{4\pi}\frac{\partial \boldsymbol{E}}{\partial t}\right]dV$. However, he overlooks the fact that he also has in his empty space a magnetic displacement current density $\frac{1}{4\pi}\frac{\partial \boldsymbol{H}}{\partial t}$ and an electric field $\boldsymbol{E}$. This electric field $\boldsymbol{E}$ and magnetic displacement current density $\frac{1}{4\pi}\frac{\partial \boldsymbol{H}}{\partial t}$ also, for equally good reason, will give an element of unbalanced force on his material system which is given by the equation $d\boldsymbol{F}_2=\left[\frac{1}{4\pi}\frac{\partial \boldsymbol{H}}{\partial t}\times\boldsymbol{E}\right]dV$.

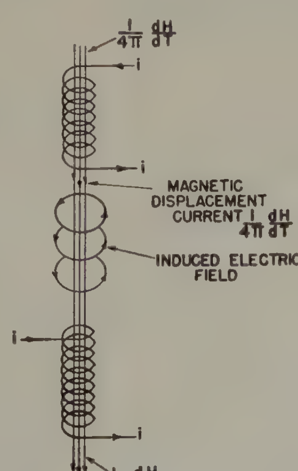

Figure 1

The total unbalanced force on his material system corresponding to each element of volume of his empty space is then, $d\boldsymbol{F}=d\boldsymbol{F}_1+d\boldsymbol{F}_2=\left[\boldsymbol{H}\times\frac{1}{4\pi}\frac{\partial \boldsymbol{E}}{\partial t}\right]dV+\left[\frac{1}{4\pi}\frac{\partial \boldsymbol{H}}{\partial t}\times\boldsymbol{E}\right]dV$ or $d\boldsymbol{F}=-\frac{\partial}{\partial t}\frac{1}{4\pi}[\boldsymbol{E}\times\boldsymbol{H}]dV$

To see the details of this force $d\boldsymbol{F}_2$ overlooked by the inventor, regard Figure 1. Here is shown the magnetic displacement current, with the plates A, B removed for greater clarity. Such an alternating magnetic flux, however, by Faraday's law, will be linked by an induced electric field as shown in the figure. This induced electric field is in just the right space position to act on the electric charges on the plates, A, B, arising from the current i, and causes a mechanical force to act on them. The induced electric field is in time phase with the electric charges so that this mechanical force is always in the same direction, but pulsating.

Unfortunately for the inventor, the time average of the force on the plates A, B is just equal and opposite in direction to the time average of the force on the field poles, correctly estimated by the inventor. Therefore the answer to the inventor's second question is "No, the unbalanced force on the space-ship cannot drive it on its journey."

However, the electric field and the magnetic field in the space between the plates are in time quadrature, so that while the two mechanical forces give a zero average resultant, the instantaneous resultant is not zero. We may answer the inventor's first question, "Yes, there will be an unbalanced net force on the space-ship of the order of magnitude estimated by him, but it will be an alternating force."

Neither the law of conservation of energy nor the law of conservation of momentum are generally true if applied only to the material parts of a system if electromagnetic phenomena are involved. However, we may regain these two laws if we assign an energy density and a momentum density to empty space. It is customary for this purpose to assign an energy density of $\frac{1}{8\pi}[E^2+H^2]$, and a momentum of $\frac{1}{4\pi}[\boldsymbol{E}\times\boldsymbol{H}]$ to empty space, where $\boldsymbol{E}$ and $\boldsymbol{H}$ are the electric and magnetic field vectors. In the inventor's system, the momentum density $\frac{1}{4\pi}[\boldsymbol{E}\times\boldsymbol{H}]$ in the space between the plates A, B is caused to vary at a rapid rate. By the reinstated law of conservation of momentum there will be an equally large but opposite rate of change in the momentum of the material system. This will correspond to an unbalanced force on the material system whose magnitude will equal $-\frac{\partial}{\partial t}\frac{1}{4\pi}[\boldsymbol{E}\times\boldsymbol{H}]$ integrated through the empty space. This force however will be an alternating one, with time-average zero, for the system shown.

J. SLEPIAN (F '27)

(Associate director, Westinghouse Research Laboratories, East Pittsburgh, Pa.)

Papers Digested for Conference on Electronic Instrumentation

These are authors' digests of most of the papers presented at the conference on electronic instrumentation in nucleonics and medicine, sponsored jointly by the AIEE and the Institute of Radio Engineers, New York, N. Y., November 29–December 1, 1948. The papers are not scheduled for publication in AIEE TRANSACTIONS or AIEE PROCEEDINGS, nor are they available from the Institute.

However, full texts of papers presented during the first day of the conference (indicated by an asterisk in the following) may be published in booklet form if the demand is sufficient to warrant such publication. Interested persons should communicate with Doctor W. A. Geohegan, Cornell University Medical College, 1300 York Avenue, New York 21, N. Y.

***Biological Requirements in Amplifiers;** *Doctor Harry Grundfest (College of Physicians and Surgeons, Columbia University, New York, N. Y.).*

Bioelectric activity in nerve and muscle fibers is a locally generated, phenomenon produced in the tissue by momentary physicochemical changes in the membrane surrounding each living cell. The recorded amplitude may vary from 100 millivolts or more in an isolated giant nerve fiber to a few microvolts when the activity is recorded from a mass of inactive, shunting tissue. The most prominent feature is an electronegative pulse lasting 0.5 millisecond to 2.5 milliseconds or more, depending upon the tissue characteristics. This "spike" is propagated by local circuit action at velocities ranging from about 150 miles per second to less than 0.1 mile per second. When it arrives at an appropriate terminal point (the synapse) it can transmit the action with a relay delay of about 0.5 millisecond. After the spike there may follow a complex of smaller, but longer lasting negative and positive after-potentials. Their durations are also characteristic for each tissue and they may last as long as one second or more.

These basic properties of the bioelectric phenomena determine the requirements for bioelectric amplifiers. The amplifier must have high maximum gain and low equivalent input noise to cope with the smallest potentials (5 microvolts or less; voltage gain about 130 decibels) and a flexible gain range (60 decibels) to measure the largest potentials observed (about 100 millivolts). The high-frequency response should be such as to reproduce events occurring within 100 microseconds (the rise time of the fastest spikes) and the low-frequency response should be adequate to record without distortion or drift excursions lasting one or more seconds. Currents of 10^{-9} to 10^{-10} ampere will affect the tissue, hence the input stage grid current should be less than 10^{-10} ampere. The tissue resistance is usually not less than 10^4 and often larger than 10^6 ohms. Hence, the input resistance should be high.

The amplifier may have to measure small potentials in the presence of much larger ones, hence it must be nonblocking. It should respond equally to single transients as well as to rapidly repeated short, sharp pulses. Hence it must be nonintegrating.

The sensitivity required of the amplifier, and the fact that small, high resistance pick-up electrodes may be placed on a relatively large animal, introduce the problem of a-c pickup. Another source of interference is the strong electrical stimulus often used to set off the bioelectric activity. Furthermore, the amplifier must be able to discriminate in favor of the potential under study and against other physiological potentials (some of much large magnitude) occurring in the animal. Often, two or more amplifier channels are to be used to record simultaneously different events. They should not intercouple or cross feed.

These requirements are met best by using differential amplifiers, several types of which are now available. Those used in the Columbia University laboratory routinely have differential action of 100,000 : 1 for out of phase against inphase signals.

The desirable amplifier is one having high differential action, a frequency band from 0–100 kc, 130-decibel gain, variable over 60 decibels, low input noise, low grid current, high input impedance, low drift. Battery-powered amplifiers, as well as partially line operated amplifiers having most of these characteristics have been available for some years. Completely line-operated amplifiers approaching these specifications have been designed recently, but the full range of requirements, particularly as to absence of drift, has not yet been met.

Bioelectric amplifiers must be designed for high reliability of operation, long term stability of characteristics, and ease of adjustment and checking. They require high-grade components, careful and roomy behind-panel layout, and a panel arrangement that permits easy adjustment of the wide range of operating conditions demanded, as well as an easy check on the steady state conditions of the various parts of the amplifier circuit.

***Instrument Requirements in Audiology;** *Doctor Aram Glorig (Walter Reed General Hospital, Washington, D. C.).*

The study of hearing may be divided into two sections—*normal* and *defective* hearing.

Instruments required to test normal hearing are basically the pure-tone audiometer and any controlled method of speech reception. The present pure-tone audiometer probably fulfills its original purpose—to do approximate tests of hearing by pure tone. To be satisfactory for good testing and still be practical, an audiometer must be more rugged and stable, particularly the receivers. The attenuators should be free from extraneous sounds and leakproof at low levels. The tone interrupter is probably more useful if designed to interrupt "on" rather than "off," or better still, arranged to do both. The weakest part of pure tone audiometry is bone conduction testing. The present oscillators do not maintain a constant equal pressure on the mastoid. There is too much air radiation. The present calibration methods are not standardized. This needs much more study.

The most important auditory stimulus is speech. The present methods make use of live voice and recorded voice. To use speech as testing material it is necessary that the highest fidelity equipment be designed. It must be easily controlled and adaptable to each individual. Whether live, monitored, or recorded signal is used the foregoing is needed.

As the proper testing of hearing must be done in rooms with a low ambient noise, designing a lightweight semiportable sound-treated room is essential. For practical use at least 40 decibels attenuation should be attained.

Because testing hearing depends on subjective response which is far from reliable, objective tests must be sought, such as changes in skin resistance in the presence of auditory stimuli.

Because the problem of deafness has reached such proportions—probably ten million individuals who need help—something must be done to make hearing aids more dependable, particularly the receivers, cords, and microphones.

The part of the electronic engineer in this field is extremely important. I would like to re-emphasize that the problem of defective hearing is important enough to warrant a great deal of work and research by the electrical engineer.

***Cathode-Ray Photography;** *Charles Berry (Cornell University Medical College, New York, N. Y.).*

The sweep speeds and maximum spot racing speeds were measured in the records published during the last ten years in physiological journals. A few records from single nerve fibers had sweeps of one millisecond, but records of other phenomena were much slower with even 20-second sweeps. The maximum tracing speed of the spot is a much more important factor in photography, and these ranged up to 55 centimeters per millisecond. When the tracing speeds were analyzed according to the type of experiment, the slowest records were from "*C*" fibers, "after" potentials, and muscle tenanus, and these were below 0.5 centimeter per millisecond tracing speed. Cord potentials were less than 7; muscle spikes less than 10; and records from central nervous system pathways were of wide range up to 40 centimeters per millisecond. Only three published records from single "*A*" or from giant axons reached 50 to 55 centimeters per millisecond.

In order to determine the speed of the camera lens necessary to photograph these phenomena, it is necessary to assume a set of possible conditions. Let us assume the physiologist has very modest equipment such as a 5-inch *CR* tube with a medium persistance screen; a 1,400-volt supply; an object to image ratio of 5 to 1; fast film; and high contrast developer. From various manufacturers measurements on their tubes and from personal experience, it can be shown

that an $f.\ 2.8$ lens will photograph a maximum tracing speed of 70 centimeters per millisecond which is sufficient to photograph all of the records found in the recent literature. However, most laboratories have higher voltage supplies and more actinic screens and with this equipment an $f.\ 3.5$ lens would be adequate.

Since biological phenomena tends to be slow and repetitive, continuous recording is desirable and moving film can be used to replace the sweep. However, this method seldom is used because the cameras are too expensive or have too high a film velocity. In the few published records, the film or paper velocities were within a very narrow range of from 1 to 10 centimeters per second. It was interesting to note that many records made with galvanometer arrangements were within the same range, and it is possible that many have used these less accurate galvanometer recording cameras because of their convenient, though limited film or paper velocities.

***Instrumental Requirements for the Electrocardiograph;** *Doctor John L. Nickerson (College of Physicians and Surgeons, Columbia University, New York, N. Y.).*

The physiological phenomenon which gives origin to the electrocardiographic pattern is the existence of small electric potentials accompanying the muscular activity of the heart. By means of electrodes attached to the body these potentials can be picked up, amplified, and recorded.

The observations which are made on these patterns to enable the clinician to determine the degree of deviation of a patient's heart from normal include the following:

(*a*). The amplitudes, in millivolts, of the major peaks and segments. Relative amplitudes are more important than absolute values.

(*b*). The time interval, in hundredths of seconds, between various portions of the pattern, for example, the *PR* interval, that is, the time from the beginning of the *P*-wave to the beginning of the *QRS* complex, and also the duration of the *QRS* complex.

(*c*). Unusual notchings in the pattern indicating some rapidly occurring variations in its generation.

(*d*). Slurring in the pattern which indicates that the voltage is being maintained at some value other than zero for a period of time longer than normal.

(*e*). General variations in shape of the major components, for example, diphasic *P*-waves, coronary-type *T*-waves, inverted waves in any portion of the complex.

The instrumental requirements necessary for the satisfactory recording are briefly as follows:

1. The electrocardiograph shall have a suitable recording mechanism.

2. The recorded response of the instrument to externally applied square wave voltages shall be adjustable to a sensitivity of one centimeter per millivolt when this voltage is applied to the leads of the instrument through a series resistance of 2,000 ohms.

3. The recording apparatus should have an adjustable damping mechanism so that the system can be adjusted to a state of critical damping.

4. The amplitude of response of the instrument to one millivolt peak sinusoidal voltage variation up to 15 cycles per second shall not fall below 90 per cent and up to 40 cycles per second shall not fall below 50 per cent of the response to an equivalent square-wave voltage variation.

5. The response of the instrument at 0.5 second after the application of the direct current of 1.0 millivolt shall not deviate more than plus or minus ten per cent from the response at 0.04 second. This test voltage shall be applied to the leads of the instrument through a series resistance of 2,000 ohms.

6. When the instrument is adjusted to the sensitivity specified in the foregoing, the recorded response shall be directly proportional to applied d-c voltages within plus or minus five per cent over a range of two centimeters on either side of zero.

7. The instrument shall incorporate a means of continuously recording time intervals on the record.

In addition to these requirements these instruments must satisfy the Underwriters' Laboratory, Inc., and the official rules of the Council on Physical Medicine.

***Electroencephalograph;** *Doctor Charles H. Richards (Cornell University Medical College, New York, N. Y.).*

The electroencephalogram is a record of the spontaneous electrical activity of the brain. The mechanism by which this activity is produced is not understood but the normal limits have been established and some types of abnormal activity have been correlated with certain disease states of the brain on a purely empirical basis. It has become, therefore, a valuable tool in the diagnosis and localization of some disorders of the brain.

The voltages obtained at the surface of the brain are of the order of 50–1,000 millivolts, but at the scalp these voltages are attentuated to 5–100 millivolts due to the shunting effect of the intervening tissue. Abnormal waves, however, may be as high as 1,000 millivolts at the scalp. The frequencies vary from 0.5 to 60 cycles per second and perhaps higher.

The present method of recording these potential changes is from small electrodes placed on the scalp with good electric contact and lead to a differential input amplifier. A direct writing recorder usually is preferred to any photographic method. The patient, either sitting or lying down, is not grounded but is placed in a shielded enclosure.

Improvement and simplification of the present apparatus is desirable. Specifically, the differential feature of the amplifier should be improved from the present 1:100 or less to 1:1,000 or more so that shielding of the patient may be less elaborate. Present amplifiers have adequate sensitivity and frequency response for clinical requirements but they will not go to zero frequency which is often desirable in research work. Probably the greatest need for improvement is in the recorder which should have a frequency response flat from direct current to 150 cycles per second.

Another problem in connection with the electroencephalogram is in methods of analysis of the wave forms and frequencies obtained. The tracings are complex and are the resultant of several frequencies of different amplitude and phase relations. Counting the obvious rhythms is a crude analysis, and although automatic analyzers have been built they do not take into account wave shape and phase relations which well may be significant. One possibility which seems to have been overlooked is that of transforming these waves to the audible range and using the ear rather than the eye as the detector. This could be done by recording at a slow speed and playing back at a higher speed. For example, a speed ratio of 1:50 would raise the frequencies to 25–3,000 cycles per second which is well within the audible range.

***Miscellaneous Recorders;** *Doctor Kendrick Hare (Cornell University Medical College, New York, N. Y.).*

Biological changes that come under study are widely diverse and include alterations in temperature, pressure, electrical characteristics, chemical composition, osmotic pressure, and so forth. The basic requirement for the design of a recorder for biological use is a detailed knowledge of the changes under observation.

If the change is electrical, the recorder must be able to follow the highest as well as the lowest frequency; the highest frequency is not that of repetition but that of the fastest component. If a high-fidelity reproduction of the wave form is not obtained, the recorder becomes an impulse counter. The size of the signal and its source impedance will determine the type of amplifier input which is preferably differential. If the change in the tissue is one of impedance an external electromotive force may be used to provide signals of convenient size for amplification.

If the changes are not electrical they can be converted into electric signals by such transducers as choppers, magnetic converters, strain gauges, transistors. In such instances the recorder must be fast enough to exceed the frequency response of the transducers and amplifiers which precede it.

There are recorders which will follow the fastest of biological changes but because of inconveniences such as lack of direct visualization, high cost of operation, and so forth, the biologist often is forced to use devices that, through poor frequency response, phase shifts, or distortion, produce records of low fidelity. The biologists need a highly adaptable multichannel recorder of economical operation preceded by amplifiers convertible from alternating to direct current and therefore adaptable to handling signals from tissue or from transducers.

***Engineering Aspects of Biological Recorder Design;** *S. R. Gilford (National Bureau of Standards, Washington, D. C.).*

With the exception of input amplifiers, instruments required by the biological investigator differ only in detail from those used in the engineering fields. The determination of instrument requirements, with special reference to bandwidth, are very difficult to determine in the biological science. This is because the sources of potential are little understood and as a consequence the frequency characteristics are unknown until recordings have been made. To determine these characteristics, wide-band recorders are utilized whose bandwidth can be decreased progressively until the point is reached where the character of the record shows modification. A more rigorous approach, infrequently used because of the difficulty of application, utilizes Fourier methods of analysis to determine the harmonic content of the signal.

In light of the previous discussion, it will be of interest to review some of the work done by the electronic instrumentation laboratory of the National Bureau of Standards, in an evaluation program applied to electrocardiographic recording. Because this type of recording has had extensive practical use, it is, in a general way, indicative of the problems encountered in biological instrumentation.

The primary interest of the evaluation program was the determination of instrument bandwidth requirements and the way these were being met by the avaiable equipment. The literature was explored to deter-

mine what work had been done to establish instrument requirements in terms of amplitude-frequency responses. The few workers who investigated the spectrum of the cardiac potential by Fourier methods seemed to agree on a minimum flat frequency response to approximately 200 cycles per second. In addition, several of the investigators** using a wide-band instrument with improved resolution noted additional characteristics, not found in electrocardiograms taken with the standard instruments, that seemed worthy of further study.

The frequency characteristics of most of the commercially available electrocardiographs were measured in the laboratory. In the United States, there are two basic types in general use. The string galvanometer, a standard in the field since the inception of electrocardiography in 1903, has a frequency characteristic flat from direct current to 40 cycles per second, falling off beyond this to 20 per cent of mid-band at 400 cycles per second. The amplifier-driven directly-recording pen, which has become increasingly popular in the past decade, has a frequency characteristic flat from 0.5 cycle per second to somewhere between 15 and 40 cycles per second depending on the individual instrument. At 100 cycles per second all the direct-writing instruments are down to approximately 20 per cent of mid-band values.

The clinical interpretation of electrocardiograms is an empirical procedure based on correlation of the characteristics of the electrocardiogram with physiological findings in illness and health. The borderline between illness and health, as a consequence, is not defined by a sharp line but rather by a zone. Undoubtedly the electrocardiogram of an individual will be modified by the instrument characteristics. However, if the errors so introduced are small compared to the spread allowable in the clinical interpretation, there exists a valid basis for clinical use of instruments having different characteristics. It is one object of this investigation, as yet uncompleted, to determine the allowable limits to these variations for clinical instruments.

In addition, it has been proved rather definitely that electrocardiograms showing additional detail will be afforded by instruments with increased bandwidths and better resolution than the instruments utilized in the field today. The meaning of this additional information will have to be studied by the cardiologist to evaluate properly its place in clinical diagnosis.

The safety factor in biological instrumentation should be given careful consideration in instrument design, since the patient usually is connected into the equipment through a low-impedance electrode system.

***Present Practice in Biological Amplifier Design;** *John P. Hervey* (*Johnson Foundation, University of Pennsylvania, Philadelphia, Pa.; now with Biological Laboratories, Johns Hopkins University, Baltimore, Md.*).

Amplifiers for bioelectric phenomena whose repetition rates lie between 10^{-1} and $5\times10^{+2}$ per second, and whose source impedances are between 10^3 and 10^7 ohms are considered herein. In general these sources contain, in addition to the desired electromotive force, explicit or implicit electromotive forces of a biological nature, as well as recognizable electrical interference from outside sources.

Necessarily considerable attention must be paid to the suppression or rejection of the unwanted potentials, and several types of "differential" amplifiers are known. It can be shown that second order variations in tubes and circuit elements prevent the realization of ideal differential amplifiers, but that suitable compensation methods make it possible to achieve apparatus in which the differential output signal arising from a common mode input of several volts is less than that arising from a differential input signal of 100 microvolts. In a discussion of the Toennies form and the symmetrical form, and the application of these methods to direct-coupled systems in which the differential gain is stabilized by negative feedback, it can be stated that the feedback as such does not control the rejection ratio. The latter appears to be determined by the grid-cathode geometry of the input tubes, as Toennies hypothesized. Low- or medium-mu triodes are superior to other types for differential input stages.

Effects of instability of supply voltages can be discussed in terms of tolerable limits on these two forms of differential stages; their advantages may be degraded substantially by even small asymmetries in the coupling circuits.

Also to be taken into consideration are various types of feedback-controlled driver circuits for oscillograph galvanometers, pen recorders, and so forth as well as high-output-voltage deflection-plate amplifiers for cathode-ray tube use. A modulated radio-frequency link circuit is a convenient method of applying signals of zero frequency or higher to the grid of the oscilloscope tube for Z-axis control.

Introduction to Nucleonics Instrumentation; *A. Dahl* (*Instrument Branch, Atomic Energy Commission, Oak Ridge, Tenn.*).

Technology in the nucleonics instrumentation field can be divided into the field of detector components and the field of metering or indication. The field of detector components is specialized in radiation detection instruments and has little relation to any other field of instrumentation, as demonstrated by the following primary types: ionization chambers, proportional counter tubes, and Geiger counter tubes. In all cases of these three types of detector components, the nuclear particles, which are detected, produce ionization within the sensitive volume of the detector component and the collected ionization is utilized in producing a response in an electronic circuit or other type indicator. The fundamental difference between these three types of detector components is the degree of multiplication, within the detector, of the initial ionization produced by the nuclear particles. Physically, all detector components can be identical to each other. The circuitry for measurement or indication of intensity of radioactivity are similar to circuits common to other fields of instrumentation, as characterized by the following terms: electrometers, pulse rate meters, d-c amplifiers, scalers or electronic counters, and audible pulse indication. Some new detectors which have not been developed into prominence in the field but which may be of importance in the future are electron multiplier counters, crystal counters, and colorimetric crystals. The photographic film also has played an important role in nuclear radiation detection.

The circuitry, characteristic of nucleonics instrumentation, is deceptively simple; however, the primary problems which are not readily detected from observation of a circuit diagram are found in the low-current high-resistance technique, which is a characteristic of this field. The currents detected are often times of the order of magnitude of micromicroamperes or less, with input resistances of the order of 100,000 megohms, which is higher than the resistance characteristic of insulators normally used in other fields of electronics. The insulators in this field, often times, must be held to resistances greater than 100 million megohms. This requirement of high resistances in the input circuits of radiation detection instruments is the primary problem in this field with regard to the electronics circuitry and has been the downfall of many manufacturers who have attempted to enter the field. In general, the circuits which have been published and used within the past 20 years are acceptable in this field; however, the knowledge of proper packaging and construction practice requires further study.

The Radiation Instruments Branch of the Atomic Energy Commission is assigned the primary responsibility of co-ordination through cognizance the various types of activities in the field of radiation detection instrumentation of all AEC installations, as well as with similar activities of the military agencies. The Radiation Instruments Branch is preparing performance requirements which establish the immediate standards of instrumentation required by the AEC installations, and these are made available to industry as a guide to producing the high quality of workmanship required.

Biological Requirements for Radioactive Isotope Measurement; *C. A. Tobias, Jr.* (*University of California, Berkeley, Calif.*), *L. Marinelli* (*Argonne National Laboratory, Chicago, Ill.*).

Some of the unsolved problems of biological isotope measurements are

1. Reliable measurement of the absolute disintegration rate of isotopic samples. Discrepancies of as much as 600 per cent have appeared when the same sample has been measured with different instruments.

2. Automatic operation of instruments. Perhaps 2,000 or more samples may have to be processed in just one biological experiment. Therefore, automatic operation of the equipment is desirable.

3. Sufficient sensitivity in gamma-ray detection. With the presently used, inefficient detectors the amounts of radioactive isotopes which must be used may endanger the organism involved. It is hoped that the recently developed scintillation counters may solve this problem since they are about 100 times as sensitive as conventional Geiger counters.

4. Microscopic studies with beta-ray radioautography. Whereas the microscopic distribution of alpha emitters within a single cell may be studied by radioautography, this is not yet possible with beta-ray emitters be-

** W. D. Reid and S. H. Caldwell, *Annals of Internal Medicine*, September 1933.

cause of scattering. Individual track emulsions seem promising.

5. Improved directional characteristics of gamma-ray detectors. The exact location of a gamma emitting substance in a living organism is often of great importance.

Geiger Counters; *H. Friedman* (*United States Naval Research Laboratory, Washington, D.C.*).

The following are some of the many processes that contribute to the mechanism of the discharge in Geiger-Mueller counters: ion multiplication within the gas by Townsend avalanche formation; spreading of the avalanches by photon absorption; positive ion neutralization by impact with molecules of admixed "quenching" gases; release of secondary electrons at the cathode by positive ions and metastable atoms; de-excitation of metastable atoms by collisons with atoms of a suitable foreign gas; electron capture by electronegative constituents in the gas; and decomposition of polyatomic molecules by electron impacts and photon absorption. Present theories provide a qualitative understanding of the fundamental roles played by all these processes, but the combined effect is too complex to predict the great variation in characteristics of tubes obtained with slightly altered practices of construction or choice of gases. Much attention has been given to methods of preparing counters so as to obtain flat plateaus, longer life, lower threshold voltage, and to eliminate spurious counts, delayed counts, temperature variations, hysteresis effects, and photosensitivity. Present developments in the use of halogen quenching admixtures, have made definite improvements in regard to temperature independence, counting life, and lowered threshold voltages.

In soft X-ray counters, the filling gas is chosen with regard to its ability to absorb the primary quanta photoelectrically. Under 50,000 electron volts, X-ray counters can approach efficiencies of 100 per cent. At higher energies, the photo effect in the gas becomes negligible and the efficiency of counting is then dependent on the cathode material. In the energy range where Compton absorption predominates, efficiencies are in the neighborhood of a per cent and increase slowly with energy.

The major problem in designing a beta counter is to provide a window capable of transmitting the primary particles. Most beta counters employ either the thin walled cathode or end window constructions. The former types are well adapted to measurements of filter paper activities and for use as dipping counters with active liquids. End window tubes are popularly used with small flat specimens. Demountable screen wall tubes and continuous gas flow counters are used where large solid angle collection and elimination of window absorption is important.

The simple coaxial wire and cylinder arrangement is not at all essential to obtaining a good plateau characteristic. For example, flat cathodes often are used. Flat plate cathodes may be stacked in multiple arrangements to improve gamma-ray efficiencies by a factor of ten. Such multiple tube construction also increases the effective resolving power for the combination in proportion to the equivalent number of individual counters.

Preferred directional response, miniaturization for use as fine probes, and background reduction for detection of weak sources, are special characteristics that often are desired. Highly directional characteristics are obtained easily in beta counters, but only limited directionality is possible in gamma counters. Extremely small counters, "needle tubes" have been constructed for interstitial probing, the limit on size being essentially mechanical. Background can be minimized by proper choice of geometry, by use of absorbing shields, and by resorting to some form of coincidence counting shield.

Thin Window Beta Counters; *Doctor F. C. Henriques, Jr.* (*Tracer Laboratories, Inc., Boston, Mass.*).

Geiger counters for the detection of low-energy beta particles must have a thin window. For example, the thickness requirements are: <3 miligrams per square centimeter for Ca^{45} and Co^{60} and <1 milligram per square centimeter for C^{14} and S^{35}. The windows usually are made of mica though sometimes collodion or nylon have been used. For very low energy beta rays such as those from H^3, it is practically impossible to fabricate a thin enough window. For such measurements the sample must be placed inside the counter. One difficulty with windows which are insulators is that the counter characteristics may be changed by the charges which collect on the window. This situation may be remedied by means of a conductive coating.

Autoradiography in Medicine; *George A. Boyd* (*The University of Rochester, Rochester, N.Y.*).

Density-exposure curves of several emulsions, using I^{131}, show the Eastman *NTB* and X-ray *M* and *A* plates to cover the range of speeds satisfactorily for autographs. The *NTB* has extremely low development fog and permits high resolution with thin sections, thin emulsions, and short development time. The density for any exposure is increased with longer development time with very little increase in fog. The two X-ray plates, *M* and *A*, are a good compromise for speed with low background.

The four techniques used today for autoradiographs, given in the order of development, are

1. The whole tissue or histological section is placed in contact with the emulsion and removed after exposure. Gross or microscopic examination of the autograph and tissue are made by side-by-side comparison.

2. A histological section is painted with liquid emulsion to give good resolution and registry. On microscopic examination, the silver grains are seen immediately above the tissue location of the radioelement.

3. The tissue is mounted permanently on a photographic plate to accomplish the same results as that of number 2. In this procedure the tissue location of the beta emitter is above the silver grains.

4. Stripping film is used by which back scattering, emulsion straining, chemical fogging, and photographic developer damage to the tissue are eliminated; blood and bone marrow smear autographs can be made; histological bodies above intense collection of grains can be identified; and grain counting for quantitation is permitted. The tissue is mounted either on the emulsion or on the cellulose ester base. For blood and bone marrow smears on glass slides, the film is laid, ester side down, on the smear.

Histological sections are prepared in either of two ways, by paraffin embedding or frozen sectioning. In the former, some activity is lost by decay because of the time involved. This is especially disadvantageous for short half-life elements. There is always the possibility of translocation and leaching out of the elements, depending on the nature of binding in the tissue and the type of solvents used in preparation for embedding. This, however, is not too serious for some preliminary work, and the paraffin technique has the advantage of being more standard routine in most histological laboratories. By the frozen sectioning technique, the autograph can be started within a few minutes after the tissue is removed from the animal or patient. Leaching and translocation are reduced. Translocation by diffusion is further reduced by keeping the tissue-autograph in a deep freeze or even at "dry ice" temperature.

Some chemical solutions for biological injection contain aggregates. This is especially true for some of the higher atomic elements such as plutonium. Since these would travel by routes different from true ionic solutions, the presence of aggregates must be determined. This is done by making autographs by quickly freezing the solution at "dry ice" temperatures to eliminate Brownian movement and prevent crystallization and placing the photographic plate on the frozen solution.

By the combination of chromatography and autoradiography, the location of radio elements in filter paper spots containing amino acids and other biochemical compounds are determined. Very small quantities of C^{14} can be determined in this manner.

The paper is based on work performed under contract with the United States Atomic Energy Commission at The University of Rochester Atomic Energy Project, Rochester, N. Y.

Biological Effects of Radiation and Health Protection; *G. Failla* (*College of Physicians and Surgeons, Columbia University, New York, N. Y.*).

Although the radiation sensitivity varies among individual cells of the same type, for example, fruit fly eggs, yet there always seems to be a safe dosage limit. Biological effects of radiation do not obey the reciprocity law, that is, the same total dosage if administered at a high rate is more dangerous than if administered at a low rate. Even apparently minor biological changes may indicate serious permanent radiation damage. It is unsafe therefore to monitor radiation dosages only by means of clinical examinations. Instead, dosage limits must be set at such levels that no biological changes whatever are expected, such dosages must be measured perforce with sensitive instruments. Our knowledge as to the safe limits is still incomplete. There seem to be some indications that the present limits should be revised. The proposed new dosage limits are the following:

1. 0.3 roentgen per week for total body radiation or 0.3 rep per week in the bone marrow.

2. 1.5 rep per week for surface exposure.

3. In emergencies, 25 roentgens in one dose for a man under 45 and 50 roentgens for a man over 45. After such an exposure the person never again should be exposed to radiation.

Health Protection Instrumentation; *F. R. Shonka* (*Argonne National Laboratory, Chicago, Ill.*).

Dosages of X- and gamma radiation are measured in roentgen units. Since the

roentgen unit is defined in terms of ionization in air, X- or gamma-ray dosages are determined by means of ionization chambers.

All other types of harmful nuclear radiation can be made to ionize gases, and, therefore, can be detected with ionization chambers. The readings of an ionization chamber will be accurate only if the beam of radiation is in equilibrium with all its secondaries and if this equilibrium is not disturbed by the walls of the chamber. Therefore, "air wall" chambers are used as primary standards. Cosmic rays and natural radioactivity produce in the ionization chamber a background of the order of one-fourth milliroentgen per day.

Very sensitive, but only qualitative, instruments may be made with Geiger counter as the detecting device.

Proportional Counters; *Sergi A. Korff (New York University, New York, N. Y.).*

A proportional counter is an ionization chamber in which the charge released in the primary ionization processes is amplified by constant factor. In a small chamber the initial charge liberated by an alpha particle exceeds that produced by a beta particle or a gamma ray; a proportional counter instrument, therefore, can distinguish between alphas and betas or gammas. In the simplest and most widely used form a cylindrical cathode surrounds a coaxial anode of a very small diameter. With this arrangement the necessary strong fields can be produced by reasonable voltages. Output voltages of 0.01 to 1 volt can be achieved. Proportional counters are faster than Geiger counters.

Neutron Detection; *B. T. Feld (Massachusetts Institute of Technology, Cambridge, Mass.).*

Neutrons being nonionizing particles must be detected by indirect means. The method employed depends on the energy of the neutrons.

1. Thermal neutrons (energy up to 0.025 electron volt). Detectors are based on the (n, α) reaction in boron or fission in uranium.

2. Resonance neutrons (energy from the thermal range up to 1,000 electron volts). Nuclear reactions yielding gamma rays or charged particles are initiated by the resonance capture of neutrons.

3. Intermediate neutrons (energy between 1,000 electron volts and 1 million electron volts). The neutrons are slowed down in paraffin to the resonance or thermal range before detection.

4. Fast neutrons (energy between 1 million electron volts and 20 million electron volts). Detection is based on proton recoil or fast neutron fission in uranium.

5. Ultrafast neutrons (energy greater than 20 million electron volts). The same techniques are used as under number 4, although in this energy range they are not as efficient.

In addition there are a number of so-called delayed detection methods, employing cloud chambers, photographic emulsions, and foils in which the neutrons induce radioactivity.

The Measurement of Ionization Chamber Currents in Instruments Designed for Health Protection; *E. W. Molloy (National Technical Laboratories, South Pasadena, Calif.).*

Practical sized ionization chambers for use with portable health protection devices demand detection of currents in the order of 10^{-14} ampere. In addition the circuits must have rapid response, and freedom from serious errors caused by battery voltage variations. Rugged output meters and simple controls are also desirable features.

The high current sensitivity specification demands close attention to the design and operation of the input tube. The classical electrometer tube is essentially an impedance changer exhibiting unity gain and high transconductance. The operation of early tubes required complex circuits with exacting adjustments, however present tubes of this type can be operated with fairly simple circuits, but it is essential to use delicate low torque output meters and instrument calibration ordinarily depends on individual tube characteristics.

If modern circuit design is applied wherein circuit operation is nearly independent of electron tube characteristics, high gain circuits with inverse feedback should be employed. The application of the classical electrometer tube to this style of amplifier results in three tube circuits. However, if the input tube can be used as an electrometer as well as a voltage amplifier, sensible design can be achieved in a 2-stage unit wherein the second stage can furnish output power and feedback voltages.

An electrometer tube with grid currents in the order of 10^{-14} ampere and exhibiting gains of 100 to 500 has been used in commercial instruments for several years. This tube is a modified *32*-type tube but recent investigation shows that the same kind of performance can be expected from certain subminiature tubes.

The present type of circuit provides stability, linearity, freedom from tube characteristic dependence, decreased response time, excellent guard potentials, multiple ranges for a single input resistor, convenient compensation for input resistor variations, and permits the use of rugged high torque output meters.

The circuit arrangement consists of a high gain electrometer tube operating with low space current followed by a low gain stage driving the output meter and furnishing feedback voltages to maintain the input grid at essentially constant potential.

Electron Multiplier Counters; *P. S. Johnson (Bureau of Ships, Navy Department, Washington, D. C.).*

Scintillation counters consist of two essential elements, a suitable phosphor which scintillates when struck by nuclear radiation and an electron multiplier phototube to detect the scintillations. The output of the photomultiplier may be fed into a pulse amplifier or into a d-c circuit.

The fluorescence properties of many substances have been studied. Those found suitable electron multiplier counters include napthalene, anthracene, phenanthrene, trans-stilbene, calcium tungstate, and thallium activated sodium or potassium iodide. Silver-activated zinc sulfide is suitable for alpha detection.

Dark current in the photomultiplier tube introduces a noise signal, which may be reduced, however, by cooling the tube. Coincidence techniques provide an alternate method of noise suppression.

Crystal Counters; *Robert Hofstadter (Palmer Physical Laboratory, Princeton University, Princeton, N. J.).*

Crystals of silver chloride at low temperatures can detect single elementary particles. Solid counters may have certain advantages over the conventional gas counting techniques, such as smallness of size, high efficiency for gamma radiation, large solid angle for detection, high speed of counting, and better conversion of energy into ion pairs, that is, better signal to noise ratio. The uses of solid counters, as now known, are more limited than indicated by the aforementioned ideas. The limitations are produced by polarization effects within the crystal, surface effects, variations in counting efficiency in different regions within the same crystal, and necessity, in the case of the silver halides and thallium halides, of employing low temperatures.

Two fundamental quantities of importance in detection with crystal counters are the mobility of electrons in the crystal, which determines the "resolving time" or "rise time" of a pulse due to ionization by a particle, and the energy required to produce an ion pair. These quantities have been measured in AgCl and AgBr crystal counters. The values of AgBr are in agreement with theory although the case of AgCl is at present unsettled. Rise times of the order of a few tenths of a microsecond may be obtained with crystals of useful dimensions for counting, and with convenient voltages. The energy per ion pair seems to be in the neighborhood of 7 to 8 electron volts for the silver halides, in contrast to about 30 electron volts for a gas.

Polarization effects within the crystal may be discussed by means of a simple electrostatic theory. The results of such a theory check with experimental measurements of counting rate as a function of total number of counts.

Photographic Emulsions for Use in Radiation Measurements; *John Spence (Eastman Kodak Company, Rochester, N. Y.)* .

The response of the photographic emulsion to radiation in the great majority of uses is evaluated in terms of photographic density. All ionizing emanations may render the silver halide grain developable to metallic silver. The density of the processed material may be correlated with the intensity of radiation. Factors which control the result for a given radiation flux are

1. The range of sensitivity of the emulsion.
2. The conditions of development.
3. The thickness of the emulsion layer.

Different commercial emulsions cover different ranges of intensities; generally large grained emulsions are the most sensitive, and by a choice of suitable emulsions a wide range of intensities may be measured. The absence of reciprocity failure and the stability of the latent image allow an accurate measure of the integrated exposure to penetrating radiations.

Nuclear particle plates are not evaluated

in terms of density but in terms of the number and nature of the tracks recorded by nuclear particles, namely, electrons, mesons, protons, deuterons, alpha particles, fission fragments. The tracks are for the most part a linear array of silver grains, and a fine grained emulsion of uniform sensitivity—grain to grain—is required. In the recording of high-energy protons, for example when the ionization per grain hit is low, the highest sensitivity and maximum development is required. On the other hand, for the selective recording of heavy ionizing fission fragments a plate of low sensitivity is required in order that the other radiations of lesser ionization may not increase the background of the plate. In general the tracks of nuclear particles in the photographic plate are evaluated in terms of their length, grain spacing, and the scattering along the track. The length of the track is determined by the stopping power of the emulsion which depends on the proportions of silver halide and gelatin present. The grain spacing for lower energy particles, for example, protons <10 million electron volts, is dependent on the degree of development. In such instances a more moderate development may give a better evaluation of the grain spacing. With thick coatings, that is, 50 microns to 500 microns, the problem of depth development has been satisfactorily attacked, by retarding the action of the developer by lowering of temperature and by dilution until complete emulsion penetration has been realized. Preswelling the emulsion with water before processing also has proved an aid in depth processing. Fading of the latent image is an important problem in nuclear particle emulsion. Physical conditions after exposure influence the effect and in general low temperature and low relative humidity reduce or eliminate latent image loss.

Plates containing light elements are available, for example, boron, beryllium, lithium. These may be used for the study of nuclear reactions and for neutron monitoring.

Cloud Chambers; *G. C. Baldwin (General Electric Company, Schenectady, N. Y.).*

The three physical phenomena involved in the formation of a cloud track are, namely, the decrease in temperature of a gas which results from a sudden expansion of its volume, the condensation of moisture from a supersaturated vapor to form drops, the production of ions in a gas by a fast particle due to interaction of the field of its charge with the atomic electrons in the gas.

The chamber used with the 100 million electron volt betatron in Schenectady is 12 inches in diameter and employs coils supplying a 4,000-gauss magnetic field. This is a piston-type chamber; the gas-vapor mixture being contained in a glass enclosure, the base of which is a movable piston. The piston is raised periodically to compress the gas; by means of an electronically-controlled tripping device it is caused to drop suddenly at the proper time of each cycle. The resulting tracks are illuminated by an intense short-duration light flash and registed photographically.

Exact timing of these operations, so that the cloud chamber and associated equipment operate in synchronism with the action of the betatron is obtained by means of thyratrons triggered through *RD* delay networks by signals from a synchronizing circuit. Other operations such as pulsing the current in the magnet coils, winding film in the camera, are initiated by means of cams. Ions are swept out of the chamber between expansions by means of an electric field applied between the piston and a transparent conducting coating on the inner surface of the upper plate of the chamber. A camera of special design with associated mirrors photographs the tracks so that a stereoscopic view is obtained.

Papers Digested for Conference on High-Frequency Measurements

These are authors' digests of most of the papers presented at the conference on high-frequency measurements, sponsored jointly by the AIEE, the Institute of Radio Engineers, and the National Bureau of Standards, Washington, D. C., January 10–12, 1949. The papers are not scheduled for publication in AIEE TRANSACTIONS or AIEE PROCEEDINGS nor are they available from the Institute.

Microwave Spectroscopic Frequency and Time Standards; *Harold Lyons (National Bureau of Standards, Washington, D. C.).*

The present primary standard of time is the mean solar day which slowly is growing longer, and fluctuates by about one part in 25 million. These and other limitations in astronomical standards make it desirable to look for new invariant and reproducible standards of time and frequency such as those using spectrum lines which also would improve world-wide frequency standardization now limited in accuracy by transmission effects in the ionosphere.

Spectrum lines of atoms or molecules in field-free regions and having very high natural Q would serve as ideal standards giving a more basic time unit than the arbitrary one provided by the rotation of the earth. The Q of spectrum lines is limited in practice by collision, Doppler, and saturation broadening. An inspection of the formulas for these effects indicates the desirability of using as high a frequency as possible in order to obtain high Q and high absorption coefficients, and also heavy molecules, low temperatures, and large absorption cells.

In the case of the inversion spectrum of ammonia, Q's of the order of 300,000 possibly might be attained. By going over to atomic beam techniques, collision and Doppler broadening can be eliminated. For a transition path length of 50 centimeters a Q of about 9 million could be obtained for a beam of cesium atoms and about 30 million for thallium.

The atomic clock using the 3,3 line of ammonia at 23,870.1 megacycles, which was developed at the National Bureau of Standards, is of the servo or frequency discriminator type. It is essentially a quartz-crystal clock which is regulated or locked by the ammonia line through a frequency-multiplier chain and servo control circuit. Frequency stability tests of the clock showed a constancy of better than one part in 20 million. The short time stability is provided by the quartz-crystal oscillator while the ammonia line determines the long time stability.

Another method of frequency control, also applicable to atomic clocks, was proposed in which absorption lines were used in circuits analogous to low-frequency quartz-crystal oscillators. These methods yield atomic oscillators or absorption-line oscillators independent of servo methods. By frequency divider circuits of the regenerative modulator or locked oscillator type the frequency could be reduced to the usual clock frequencies. The atomic oscillators are of the feedback type in which regenerative feedback to a microwave amplifier is controlled by an absorption cell. One such oscillator which was tested in an equivalent circuit design transmits the feedback signal through a magic-tee in which the cell terminates one impedance arm. Another oscillator uses a 6-arm junction as a waveguide Wheatstone bridge with the absorption cell used as one of the bridge terminations. A precision, absorption-line oscillator suitable as a frequency and time standard could be made in this way largely independent of external parameters. The lines of deuterated ammonia are being investigated for use in these oscillators.

An atomic beam clock of the servo-type, using a locked quartz-crystal oscillator and multiplier chain, offers the greatest potential for ultimate accuracy as a primary frequency and time standard. A potential accuracy of one part in ten billion or greater is indicated.

Frequency Stabilization With Microwave Spectral Lines; *W. D. Hershberger (RCA Laboratories, Princeton, N. J.).*

In the microwave frequency stabilization

system,[1] a sweeping oscillator is employed to compare the frequency of a molecular spectral line f_m, and the operating frequency of a klystron f_k, and the relationship between the two frequencies is given by

$$f_k = \frac{f_m \pm f_e}{n}$$

where n is a whole number, and f_e is a relatively low off-set frequency or zero. As a result of the comparison an error voltage is developed and used to stabilize frequency.

The stabilizer acts degeneratively on frequency modulation impressed on the klystron over a frequency range limited ultimately by the band width of the spectral line, since the effective time constant of the filter in the servoloop is reduced by the stabilization factor $(1+\mu)$. This factor in the present system has been increased to well over 10^5. If Δf_0 represents the frequency change experienced by an unstabilized klystron due to an impressed disturbance, the stabilizer serves to reduce the change actually experienced by a stabilized klystron subjected to a similar disturbance to

$$\Delta f_0' = \frac{1}{1+\mu}\,\Delta f_0$$

Thus the short-term frequency stability depends both on the magnitude of an impressed disturbance and on loop gain μ.

The chief merit of the present stabilizer resides not so much in its high short-term stability realized by high loop gain as in its long term stability. Stability of this variety depends on how well and with what degree of permanence a set-point or reference frequency is established, namely, that frequency for which discriminator output changes sign. Uncertainties or drift in set point frequency are reproduced in the output frequency with fidelity given by the factor $\frac{\mu}{1+\mu}$. Thus if set-point frequency is changed by the amount Δf_s, for example by introducing a change in f_e, the output frequency change is given by

$$\Delta f'_s = \frac{\mu}{1+\mu}\,\Delta f_s$$

The two methods of introducing changes of frequency may be combined to accomplish wide band frequency modulation.

The ultimate basis of set-point stability is the molecular spectral line with its Q of 10^5 or higher. In the present state of the art, one need not differentiate between "molecular" or kinematic time and "dynamical" time.[2] However, it is not unlikely that data from molecular clocks will play an important role in testing current hypotheses on the origin of the red shift of astronomy.

Two stabilizers are now in use in experiments on short-term stability. Also some experimental work has been conducted on sealed off wave guide cells to hold ammonia at reduced pressure. Measurements on long-term stability will obviously require long-term frequency comparisons. An analysis of sources of error indicates that with an initial line Q of 10^5, long-term stability of 1 part in 10^7 is realized. This means that the servo loop is required to hold in time coincidence two wave forms arising from resonance phenomena to within $\frac{1}{100}$ the width of either. Further progress with systems such as the present one, in which a frequency comparison is made on the basis of time or phase, will depend on close attention to the characteristics of the method used in converting frequency to time or phase, to the constancy of amplifier characteristics, and to the differences in shape between resonance curves characterizing molecular spectral lines and those characterizing tuned electric circuits.

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The Stabilization of Microwave Oscillators; *E. W. Fletcher (Cruft Laboratory, Harvard University, Cambridge, Mass.).*

The problem of stabilizing a microwave oscillator using a cavity resonator as a reference standard was recognized and developed by R. V. Pound at the Massachusetts Institute of Technology radiation laboratory. Pound used a high-Q cavity as a frequency control element for a klystron oscillator by making a frequency comparison between the oscillator and the reference cavity.

Pound first used a direct-coupled amplifier in the feedback loop, and later, to overcome difficulties with drift and low-frequency noise, he developed an intermediate-frequency system at 30 megacycles per second.

One problem to consider is that of the reduction of noise in the klystron and its associated power supply circuits. This noise stems from three principal sources: shot noise, power supply instability, and variations in ambient conditions.

An analysis treating the stabilization system from a conventional servo point of view indicates that an improvement in stability may be had with a higher-Q reference standard. In a study of the problem of high-Q reference standards, including both cavity resonators and molecular absorption lines, it is shown that the latter has distinct advantages as a reference standard.

This research was made possible through support extended Cruft Laboratory, Harvard University, jointly by the Navy Department (Office of Naval Research), the Signal Corps of the United States Army, and the United States Air Force, under ONR Contract N5ori-76, T. O. I.

Superconducting Resonant Cavities—Measurements of the Surface Impedance of Normal and Superconductors at Low Temperatures and Microwave Frequencies;* *E. Maxwell (Massachusetts Institute of Technology, Research Laboratory of Electronics, Cambridge, Mass.; now with the National Bureau of Standards, Washington, D. C.).*

Measurements have been made on the properties of resonant tin cavities at temperatures down to two degrees Kelvin and at a frequency of 24,000 megacycles per second. Interest centers both in the behavior in the normal state at temperatures of 30 degrees Kelvin, and below as well as in the superconducting behavior. In the normal state it is found that the cavity Q does not rise proportionately as the d-c conductivity is increased by lowering the temperature but rather reaches a limiting value which is independent of the temperature after about 15 degrees Kelvin. The limiting value is a characteristic of the metal and the frequency. This anomalous behavior is due to the fact that the electronic mean free path becomes large compared to the skin depth and consequently the simple conductivity concept becomes inadequate at these temperatures. Instead one uses the surface impedance concept, which defines the conducting property of the metal in terms of the ratio of tangential E to tangential H at the surface of the metal.

A large and relatively sudden increase in the Q is observed when the temperature of the cavity is lowered beyond the superconducting transition temperature. The transition is not as sharp as observed in the case of direct current nor does the resistance vanish completely as for the d-c case. Q's of the order of a few hundred thousand to a few million may be obtained.

The measurement techniques center on methods of measuring high Q's. Several schemes, separately and in combination, have been used. In some cases resonance curves were taken using pound stabilized continuous-wave oscillators and either a slotted section or magic tee for measuring input standing wave ratio as a function of frequency. For rapid measurements a scheme using frequency-modulated klystron together with a magic tee, crystal detector and oscilloscope was employed to give visual display of the resonance absorption of the cavity. This arrangement permits rapid measurement of the standing wave ratio at resonance and, hence the ratio of unloaded to window Q, as a function of temperature.

* This work was supported by the Army Signal Corps, Navy Department, and Air Force under Signal Corps Contract W-36-039-SC 32037.

Sources of Power for Microwave Measurements; *George E. Hackley (Sperry Gyroscope Company, Great Neck, N. Y.).*

The characteristics required of the power source for microwave measurements are quite varied and they are determined by the sensitivity of the measuring equipment and by the measurement being made. For most purposes a power output of about one watt is adequate, although some special measurements, particularly voltage breakdown tests, require very large powers. Good frequency stability is quite important in measurements of narrow-band or resonant circuits, while wide tuning ranges are required for broad-band testing of components. The source should be easy to frequency modulate and amplitude modulate. To obtain all of these varied characteristics, there are a number of different types of sources of power, although no single type fulfills all of the requirements.

Triodes may be used as amplifiers, multipliers, or oscillators at frequencies up to about 3,000 megacycles with power outputs up to 25 watts. They are not easily frequency-modulated, but they may be pulse-modulated easily to obtain very high values of peak power. Triodes are most useful

as power sources at frequencies below about 2,000 megacycles.

Magnetrons, which are oscillators, may be used from a few hundred megacycles to about 50,000 megacycles, although they are not available for every frequency within this range. Most magnetrons are fixed tuned and must be pulsed, but a few continuous wave and narrow tuning range ones are available. Frequency-modulated magnetrons have been designed, but they are not generally available. Peak powers of kilowatts or megawatts may be obtained from magnetrons. As a power source for microwave measurements, magnetrons are most useful for high-power testing of components.

Crystal rectifiers may be used as harmonic generators to provide very small amounts of power at frequencies up to 50,000 megacycles or more. Because of the small amount of power that may be obtained, they are most useful at frequencies where other sources of power are not available or where only small powers are needed, as in frequency standards.

Traveling wave tubes, which are in the experimental stage at present, are wide-band amplifiers which may prove to be quite useful as power sources. They may be used as oscillators, by providing feedback through a resonant circuit, over fairly wide ranges with power outputs in the order of one watt at a few thousand megacycles.

Klystrons, which are available as amplifiers, multipliers, and oscillators, are the most useful of the sources of power for microwave measurements and they may be used at frequencies up to 50,000 megacycles. Klystron amplifiers and multipliers are rather narrow-band devices and they are most useful for fixed frequency applications, as in frequency standards. Power outputs of over 100 watts may be obtained from klystron amplifiers at 3,000 megacycles and correspondingly less power may be obtained at higher frequencies. Reflex klystrons, which are oscillators with only one resonant circuit, are the most useful and available source of microwave power. Power outputs of reflex klystrons range from over 10 watts at 2,000 megacycles to more than 5 milliwatts at 50,000 megacycles. Reflex klystrons are tuned easily and may be frequency, pulse, or square-wave modulated.

Bolometric Measurement of Microwave Power Over Broad Frequency Bands;*

Herbert J. Carlin (Microwave Research Institute, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.).

The most usual practice in the application of bolometers for the measurement of microwave power is to use a substitution procedure which equates low-frequency power to microwave power by means of a Wheatstone bridge. For this method to be valid, it is desirable that the following general design criteria be satisfied:

1. The bolometer cross-sectional dimensions should be less than the skin depth to insure similar radio-frequency and bias power distributions over the bolometer cross section.

2. The bolometer should be short compared to wavelength to insure similar radio-frequency and bias power distribution along the bolometer length.

3. The bolometer should be long compared to cross-sectional dimensions in order that the thermal properties be uniform along the bolometer length.

4. The static resistance-power curve of the bolometer should be linear. If this, as well as number 3, is closely satisfied, then the substitution method is valid independent of the longitudinal radio-frequency versus low-frequency power distribution. In addition, linearity minimizes some of the errors due to a pulse modulated radio-frequency signal.

5. The bolometer should have a relatively long thermal time constant. If not, the bolometer resistance follows a pulsed signal and the null detector of the substitution bridge circuit has a varying component of current. This leads to an incorrect bridge balance and a resulting error under pulsed conditions.

It is desirable that a bolometer power meter operate over as broad a frequency band as possible with a fixed tuning adjustment. The Microwave Research Institute of the Polytechnic Institute of Brooklyn has developed a series of 6 power meters which cover the frequency band 20–10,000 megacycles per second, and a power range of 25 microwatts to 5 watts. The maximum voltage standing wave ratio is 1.30, representing a maximum of one per cent reflection loss with a matched generator. Extremely broad-band performance is obtained by means of an adjustable short-circuiting slug at the back of the bolometer, and an adjustable undercut section of line in front of the bolometer. These tuning devices cancel the parasitic reactance associated with the bolometer. They are set experimentally for optimum voltage standing wave ratio over the desired frequency band and then locked permanently in position.

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Microwave Metallized-Glass Attenuators;*

J. W. E. Griemsmann (Microwave Research Institute, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.).

In addition to the known applications of microwave attenuators in signal generators and as multipliers for power meter, attenuators occupy a place of considerable importance in the whole field of microwave instrumentation.

Both wave guide and coaxial attentuators have been developed for specific broad bands of frequencies in the over-all range from 0 to 25,000 megacycles per second. A set value of attentuation is dependent in only small measure upon the frequency, a typical band for the coaxial fixed value attenuator being 1,000 to 4,000 megacycles per second. The input and output impedances are matched in any case to a voltage standing wave ratio value of less than 1.3. In the case of the variable waveguide attentuators, the low minimum insertion loss (<0.5 decibel) increases greatly the usefulness of these instruments for measurements.

All of the attenuator developments use, as the basic dissipating element, a very thin resistive metallic film formed on glass. Films of noble metals alloys or nichrome are used.

Coaxial fixed pads in the attenuation values 3, 6, 10, and 20 decibels have been developed for the frequency range 4,000 to 10,000 megacycles per second, 1,000 to 4,000 megacycles per second and 0 to 1,000 megacycles per second.[1] The designs of the coaxial units are based on distributed parameter transmission line theory and are constructed on the basis that the resistance per square measured at power or audio frequencies is identical to that active at the microwave frequencies. Special equivalent circuit techniques were derived for frequencies below 4,000 megacycles per second which allow analytical design of the extremely broadband "chimney" types of attenuators. Departure from the distributed parameter transmission line theory occurs when the attenuation rate becomes very high.

Continuously variable waveguide attenuators have been developed with satisfactory performance over the full useful range of the waveguide. The following table gives the sizes of units developed and their corresponding performance characteristics.

Guide Size (In.)	Frequency Range (kmc/sec)	Maximum Insertion Loss (Decibel)	Attenuation Spread at 40-Decibel Attenuation
$1/2 \times 1/4 \times 0.040$	18.0 to 25.6	0.5	±2.5
$1 \times 1/2 \times 0.050$	8.3 to 12.15	0.5	±1.3
$2 \times 1 \times 0.057$	3.95 to 5.85	0.5	±1.5

For the vast majority of settings the voltage standing wave guide is less than 1.1, but, in any case, the voltage standing waveguide never exceeds 1.2.

Development on the $1\frac{1}{4}$ inch by $\frac{5}{8}$ inch guide size is nearly complete and that on the 3 inch by $1\frac{1}{2}$ inch started.

The first attenuator in the list is of the guillotine type in which a resistance film formed on a thin insulating glass base is introduced through a slot in the top or broad side of the waveguide. The performance, particularly the attenuation spread, is critically dependent on those factors which control the feed of current to the resistance film. Better performance is obtained for very thin insulating base, such as the 0.007-inch mil glass plate used in the foregoing attenuator.

The remaining two attenuators are the vane type which uses a flat metallic resistive plate with surface parallel to the electric field lines. Variability is attained by moving the plate from the side of the waveguide into the more intense fields at the center. The performance which can include such occurrences as a "resonance-like" attenuation curve are dependent critically on the plate width and resistivity again as a result of the method of feeding currents to the resistance film.

Other special broadbanding applications for the resistance films are anticipated.

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* The developments described have been sponsored by the Navy Bureau of Ships and Watson Laboratories, AMC, United States Air Force under contracts with Polytechnic Institute of Brooklyn.

The Effective Conductivity of Wires at Microwave Frequencies;

A. C. Beck, R. W. Dawson (Bell Telephone Laboratories, Holmdel, N. J.).

When studying the attenuation of coaxial lines and waveguides at microwave

frequencies, it is desirable to know the heat loss in the metal itself for different materials and surface conditions. To obtain this information, equipment was set up to determine the effective conductivity of small wire samples at frequencies in the order of 9,000 megacycles.

A short piece of the sample to be tested is supported by polyfoam beads in an open-ended tube somewhat longer than the sample. The resulting open-circuited coaxial line is excited through an opening from a terminated waveguide by a signal oscillator which is frequency-modulated about a resonant frequency of the line. The signal taken into a second waveguide through an opposite opening in the coaxial line is connected to a superheterodyne receiver whose beating oscillator is frequency-modulated in synchronism with the signal oscillator. The output of this receiver is the resonance curve of the test line. A cathode-ray oscilloscope is switched at a 30-cycle rate between this output and the trace of the rectified envelope of the signal oscillator on which a frequency marker from a tunable resonant cavity wavemeter is superimposed. By using an accurately calibrated attenuator to determine the levels, the half-power bandwidth of this resonance curve is measured with the cavity wavemeter. The Q is determined by dividing the frequency at resonance by this bandwidth. It is corrected for coupling losses by measuring the transmission loss through the specimen holder at resonance. Corrections are made also for outer conductor losses and end effects. As a result, the absolute effective conductivity of the wire sample is obtained.

Measurements on commercial wires of high conductivity, such as silver, copper, gold, and aluminum, give Q values about 85 to 90 per cent of those calculated from the measured d-c conductivity. Wires of lower conductivity, such as molybdenum, platinum, brass, and phosphor bronze, give values from 90 to 100 per cent of the calculated value. Very smooth electropolished copper wires measure close to 100 per cent, but drop to about 95 per cent if left exposed in the laboratory unless lacquered. This indicates the importance of a smooth surface, especially for high conductivity samples, at these frequencies where the current skin depth is so exceedingly small. Smooth copper wires rubbed lengthwise with fine emery cloth dropped to about 80 per cent of their initial value, and rolled between ground steel plates to produce circumferential grooves about three microns deep dropped to about 60 per cent of their initial value. A copper wire with 220 threads per inch had only 40 per cent of its initial Q. Copper electroplated on very smooth electropolished copper wires gave values about 80 per cent of the initial value, and when re-electropolished the value was only 95 per cent of the original value. Silver electroplated on very smooth electropolished copper wires from a cyanide bath at various rates gave Q values from 45 to 75 per cent of the initial value, the higher results for the smoother platings. Only a few plated samples have been measured so far, and this work is being continued.

As a check on the accuracy of the equipment, it was found that very smooth samples of platinum, phosphor bronze, brass, molybdenum, 24 carat gold, and copper gave results within two per cent of the Q value calculated from their measured d-c conductivity. These metals have Q's spread over the range from 800 to 2,100 when used in this specimen holder.

The information obtained with this measuring equipment has been found useful in the design and treatment of microwave components of all types where loss is a factor of importance.

X-Band Phase Shiftless Power Splitter;

Henry J. Riblet (Submarine Signal Company, Boston, Mass.).

For some time, there has been a recognized need for an item of X-band test equipment which will act as a continuous power divider without introducing any relative phase shift between the output voltages. A device which will do this for a 30-decibel range in power division, at all frequencies in the X-band, within a tolerance of about ± 1 degree, consists of a directional coupler of the perpendicular slot variety[1] in which the common wall between the wave guides may be moved laterally between the guides. The trick depends on the fact that by placing the longitudinal slots on only one side of the guide, it is possible to vary the plate from the position of maximum power transfer to the position of minimum power transfer without encountering any current discontinuities.

In the experimental model, a sufficient number of slots were used so that it behaved essentially as a hybrid when adjusted for maximum power transfer. For minimum power transfer the insertion loss was about 35 decibels or 0.1 decibel depending on which of the output terminals was investigated. Thus, operating simply as an attenuator, the device covers the attenuation range from 0.1 decibel to 35 decibels.

The fact that it splits power without introducing any relative phase shift between the output voltages depends on its symmetry as lossless directional coupler. If φ is the relative phase between the output voltages, if δ is its directivity, and if ρ is the magnitude of its reflection coefficient, it is a rather simple matter to show that

$$|\cos \varphi| \leq \epsilon\sqrt{\delta}\rho,$$

where ϵ varies from 1.4 for hybrid performance to 1 for no power transfer. Over most of the range of operation of this device there is no difficulty in obtaining directivities > 20 decibels and standing wave ratios $\leqslant 1$ decibel. Hence $\sqrt{\delta} \leqslant 0.1$ and $\rho \leqslant 0.06$. Thus $|\cos \varphi| \leqslant 0.01$ and 89 degrees $< |\varphi| < 91$ degrees.

The experimental results confirm this estimate in that, for five frequencies covering the 12 per cent X-band and for all attenuations ranging from 0 decibel to 30 decibels, the relative output phases are constant to within ± 1 degree. Slight deviations of this constant from 90 degrees may be attributed to mechanical assymetries.

In addition to its use as a phase shiftless power divider, it serves quite nicely as a directional coupler and very stable calibrated attenuator. In this connection we have used it extensively as a medium power attenuator for duplexer measurements.

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A Figure of Merit for Directional Couplers;

George James (Sperry Gyroscope Company, Great Neck, N. Y.).

Two definitions of the concept of directivity appear in the literature. One of these, intrinsic directivity, measures the properties of the coupling structure only and is limited in significance except to the designer of directional couplers. The second, effective directivity, takes account also of the properties of the secondary line termination, has the properties of a figure of merit and is readily measured.

In order to display the properties of the concept of effective directivity we consider a generic coupler in which the primary line amplitude is assumed to be unity. Secondary line amplitudes are taken to be A_1 and A_2 in the high and low level ends respectively. The primary line load is assigned the coefficient of reflection r_1 and r_2 is the coefficient of reflection of the secondary line termination.

Using this terminology we define:

1. Coupling: $C = 20 \log \dfrac{1}{A_1} = -20 \log A_1$.

2. Directivity coefficient: $d = A_2/A_1$.

3. Intrinsic directivity:
$$D = 20 \log A_1/A_2 = 20 \log \frac{1}{d}$$

4. Effective directivity:
$$D_{eff} = 20 \log \frac{1}{|de^{j\varphi i} + r_2 e^{j\varphi ii}|}$$

Where A is total resultant amplitude incident on M and φi and φii are phase angles determined by the electrical lengths of the paths of propagation within the coupler, by the phase angle of r_2, and by the phase shifts in the coupling device.

In measurement of power we consider first the effects of the parameters r_1, r_2, and d upon the accuracy of power measurement with a directional coupler. It may be shown that the amplitude of the wave incident upon the response device M is

$$A_1 |1 + r_2 de^{j\varphi iii} + r_1 e^{j\varphi iv}(de^{j\varphi ii} + r_2 e^{j\varphi ii})| \qquad (1)$$

where all terms of order three or greater in r_1, r_2, d have been ignored. Since r_2 and d are inherent properties of the coupler and since the paths of propagation which affect φiii do not involve reflection from r_1, the term $r_2 de^{j\varphi iii}$ may be and usually is included in the calibration of the instrument. The measurement of relative power level involves an error in amplitude determined by the phase difference between the vectors

$$1 + r_2 de^{j\varphi iii} \qquad (2)$$

and

$$r_1 e^{j\varphi i_v}(de^{j\varphi i} + r_2 e^{j\varphi ii}) \qquad (3)$$

and will be greatest for phase differences of either 0 or 180 degrees between equations 2 and 3. Thus the maximum error in power measurement is approximated by

$$r_1 / de^{j\varphi i} + r_2 e^{j\varphi iii} / \qquad (4)$$

It may be shown also that the error in measurement of coefficient of reflection using a directional coupler is approximated by

$$/ de^{j\varphi i} + r_2 e^{j\varphi iii} / \qquad (5)$$

Equations 4 and 5 each may be represented in simple graphical form.

A Precise Direct Reading Phase and Transmission Measuring System For Video Frequencies; *D. A. Alsberg, D. Leed (Bell Telephone Laboratories, Inc., Murray Hill, N. J.).*

An insertion phase and transmission measuring system has been developed which combines laboratory precision of measurement with speed of operation suitable for use in production testing. The system covers a frequency range of 50 to 3,600 kc. Its accuracy is in excess of ±0.25 degree in phase over a continuous range of 360 degrees, and ±0.05 decibel in transmission over a range from 60-decibel loss to 40-decibel gain. A heterodyne measurement method is used.

Reactance tubes automatically control the slave oscillator frequency from the outputs of a pair of discriminators, a frequency discriminator with an output proportional to frequency error, and a phase discriminator with an output proportional to the integral of frequency error. This combination maintains the slave oscillator at 31-kc difference with respect to the master oscillator without sideband ambiguity. The d-c loop gain is effectively infinite and the frequency error therefore zero. The frequency discriminator insures noncritical lock-in.

The circuit accuracy is limited by the range over which a frequency converter responds linearly to input voltage changes. A *6AK5* vacuum tube is used as a square-law-type converter. A linearity of 0.01 decibel is obtained over an input voltage range of more than 30 decibels.

An equal 4-arm phase bridge with two outputs is used as the phase sensitive element in the detector. Equality between these outputs defines the null of the system regardless of the input voltage amplitudes to the bridge. Amplitude difference between these outputs measures directly phase difference between the input voltages, independently, to a first order, of input amplitude inequalities.

The phase shifter employs a 4-quadrant variable sine capacitor. The residual error of the phase shifter is corrected automatically by an optically projected moving index. Linear scales may be set to establish an arbitrary zero reading. Unique balance indications of the phase bridge occur every 360 degrees and define an absolute standard of 360 degree phase shift. Exact submultiples of 360 degrees are generated from this standard by the method of substitution and used to produce the optical corrector. The phase shifter is calibrated to an absolute accuracy of better than ±0.1 degree. Higher accuracy could be obtained with the calibration circuit if the need arose.

By means of a simple automatic dial lighting system the measuring attenuator indicates directly the gain or loss of apparatus under test.

The following are the main features.

The measurement of phase is unambiguous with respect to quadrants and the measurements of insertion phase and loss or gain are independent of each other. The entire frequency range is covered without band switching by use of a heterodyne signal oscillator, and the system zero is independent of measurement frequency. Detector tuning is eliminated through the use of frequency conversion, employing a beating oscillator automatically controlled in frequency by the signal oscillator. Phase and transmission may be read directly, without auxiliary computations, from the dials of the phase shifter and attenuator or the scales of indicators.

Methods of Measuring Impedance and Voltage Standing-Wave Ratio at Microwave Frequencies; *F. Klawsnik (Sperry Gyroscope Company, Great Neck, N. Y.).*

The following methods may be considered.

Standing Wave Detector. That deep probe penetration, makes it possible to obtain exact results even from badly distorted patterns is illustrated. A variation is the use of line stretchers on one or both sides of a fixed probe.

4-Probe Sampling of Electric Fields. The two probes of each pair are separated by a quarter wave length and the pairs are staggered by an eighth wave. The output from each probe goes to a crystal detector. The difference in the output of each probe of one pair ($2V_iV_R\cos\theta$) is impressed on the horizontal plates of a scope and the difference in the output of each probe of the other pair ($2V_iV_R \sin\theta$) is impressed on the vertical plates. When the microwave source is frequency-modulated, a trace of the reflection coefficient will appear on the scope. With adjustable probes the impedance can be read to better than five per cent for the full bandwidth.

2-Slot Sampling of the Electromagnetic Fields. Two cross guides, one either side of the main guide, are coupled to the main guide through a slot. One slot is excited by the total longitudinal current flow and is proportional to the vector difference of the incident and reflected voltages. The other slot is excited by the total transverse current and is proportional to the vector sum of the incident and reflected voltages. The input to the main guide is frequency-modulated. The output from the two cross guides is $V_i+V_R+2V_iV_R\cos\phi$ and $V_i+V_R-2V_iV_R\cos\phi$. The ratio of these outputs is applied to the vertical plates of a scope and the horizontal plates are connected to the sweep frequency. The trace on the scope will represent the square of the voltage standing wave ratio. This method can be used over a 12 per cent frequency range and gives an accuracy of 8 per cent in magnitude and 4 per cent in phase.

Microwave Bridges. Two types of bridges are the 6-arm exact equivalent of the Wheatstone bridge, and the hybrid circuit used as a bridge. In the 6-arm bridge the voltage standing wave ratio is determined by three physical lengths. Here it is possible to measure any impedance with about the same accuracy as with a standing wave detector.

Most hybrid circuit bridges are not balanced to a null but are based on the fact that the output is proportional to the square of the reflection coefficient of the test piece when one arm is terminated in a matched load. An indicator on the output arm can be calibrated in voltage standing wave ratio. For badly mismatched test pieces a movable short circuit may be used instead of the matched load and then the output is a measure of one minus the reflection coefficient.

The reflectometer is an extension to directional couples of the hybrid circuit bridge for measuring the voltage standing wave ratio.

Resonance Cavity. The length of a resonant cavity is determined by the magnitude and position of a discontinuity in this cavity. With adjustable shorts it is possible to form a cavity and to move it relative to a discontinuity on the line.

The varying length of the cavity is a measure of the magnitude of the reflection coefficient. If proper precautions are taken it is possible to measure both extremely low voltage standing wave ratios in the order of 1.002 to an accuracy of one-tenth of one per cent and also to measure extremely high voltage standing wave ratios in the order of 7,000 to 1 to an accuracy better than one per cent.

This method is used to measure nondissipative elements such as slot couplings, windows, steps, connectors, and posts to very extreme accuracies.

Generator Mismatch Measurements in Transmission Lines; *Peter E. Gilmer (Bell Telephone Laboratories, New York, N. Y.).*

The mismatch "looking back" along a transmission line towards an active signal generator or source can be measured by the following simple method. This method is valuable because a mismatched generator can cause signal distortions in communications systems and errors in measurements.

The interaction, or repeated reflection effects, that are responsible for the distortions and errors just mentioned, are utilized in the measurement. The method amounts to varying the phase between the generator and a purposely mismatched load. Multiple reflections between the generator and the load cause the output to change as the phase is changed. The generator mismatch can be determined by proper interpretation of the measured output variations.

A device that can be used to measure the generator mismatch in rectangular waveguide consists of the following. A coupling loop projects through a movable short-circuiting piston and connects to a coaxial plug attached to the back of the piston. In this particular device a crystal detector is built into the center conductor for use with a single detection circuit or a d-c milliammeter. The procedure is as follows:

1. Insert the piston into a length of waveguide so that the piston "looks back into" the generator mismatch to be measured. The generator must be turned on.

2. Connect an indicating circuit to the piston output connection.

3. Move the piston over a range of at least a half wave length in the guide.

4. The output will be observed to vary in much the same manner as if a standing wave detector were being used in a conventional measuring circuit. Note the ratio of maximum to minimum current picked up by the loop, S_a, an apparent standing wave ratio. Account must be taken of the detector characteristic.

(*a*). For an approximate solution, the generator standing wave ratio, S_g, is approximately equal to the apparent standing wave ratio, S_a. This assumes that the reflection coefficient of the piston, ρ_p, is almost unity and is large compared to the reflection coefficient of the generator, ρ_g.

(*b*). For an exact solution, use the following equation. The reflection coefficient of the piston, which must be known for this case, can be measured by conventional means:

$$\rho_g\rho_p = \frac{S_a-1}{S_a+1}$$

The reflection coefficient of the piston should be chosen keeping the following limitations in mind. A small reflection coefficient reduces the sensitivity of the measurement. In some instances, a large reflection coefficient is undesirable. The varying load presented to the generator by the movement of the piston may pull the frequency or output of the generator.

This method can be used also to measure the mismatch of a 4-terminal network if the generator impedance is first matched to the transmission line and then the unknown net-

work connected in tandem with the generator.

If it is desired to use this method for measuring very small mismatches, the piston must be designed carefully and it must be used in a precision section of wave guide so as to keep the reflection coefficient of the piston constant.

A Method of Measuring Phase at Microwave Frequencies; *Sloan D. Robertson (Bell Telephone Laboratories, Inc., Holmdel, N. J.).*

A method of phase measurement using a homodyne detection principle which operates in the following manner. The output of a microwave signal oscillator is divided in two portions. One portion is applied to a balanced modulator where it is modulated by an audio-frequency signal. The suppressed-carrier double-sideband signal from the modulator is applied to the device whose phase shift is to be measured. Means are available for sampling the signal at both the input and output of the device. The other portion of the oscillator power is fed through a calibrated phase shifter and is applied to a crystal detector in the manner of a local oscillator of a double-detection receiver. The signal samples then are applied alternately to the crystal detector where they are demodulated by the action of the homodyne carrier. In each case the phase shifter is adjusted so that the audio signal disappears in the detector output. This occurs when the phase of the homodyne carrier is in quadrature with the signal sidebands. The difference in phase between the two adjustments of the phase shifter is equal to the phase difference between the two samples. The apparatus can be assembled with standard waveguide components.

Dielectric Measurement Techniques in the Very-High-Frequency Region;† *W. B. Westphal (Laboratory for Insulation Research, Massachusetts Institute of Technology, Cambridge, Mass.).*

High-frequency measurements of dielectric properties are based on the interaction between the material and electromagnetic waves. The dielectric constant (ϵ^*) and the magnetic permeability (μ^*) are complex numbers expressing the ratio of flux density to field intensity for the electric (E) and magnetic (H) fields respectively. The ratio of energy dissipated to energy stored defines the loss tangent for material:

$$\epsilon^* = \epsilon' - j\epsilon'' \quad \tan\delta_d = \frac{\epsilon''}{\epsilon'}$$

$$\mu^* = \mu' j\mu'' \quad \tan\delta_M = \frac{\mu''}{\mu'}$$

For a transverse wave travelling in an infinite medium, the ratio E/H gives the intrinsic impedance $\left(Z = \sqrt{\frac{\mu^*}{\epsilon^*}}\right)$ for the material. The progress of the wave is characterized by the complex propagation constant:

$$\gamma = j\frac{2\pi}{\lambda}\sqrt{\epsilon^*\mu^*} = \alpha + j\beta$$

† This work was supported jointly by the Navy Department (Office of Naval Research), the Army Signal Corps, and the Air Force (Air Materiel Command) under ONR Contract N5ori-07801.

In principle, the obvious measurements would be of amplitude at two points to determine α, a phase difference measurement at two points to determine β, and a complex impedance measurement at one point. If a normal reflecting boundary is added to the system, a standing wave pattern is produced which eliminates the necessity for instantaneous phase measurements. Instead, the distance between successive minima is a measure of β and the envelope decay characteristic determines α. In addition, an impedance measurement at one point is necessary. Alternately, impedance measurements at two points determine the desired quantities.

Measurements of either the E or H standing wave pattern in a known medium, terminated in a slab of unknown properties, determine the impedance at the boundary:

$$Z_B = Z_{01}\frac{\dfrac{E_{min}}{E_{max}} - j\tan\dfrac{2\pi X_0}{\lambda_1}}{1 - \dfrac{E_{min}}{E_{max}}\tan\dfrac{2\pi X_0}{\lambda_1}}$$

Z_{01} = the intrinsic impedance of the known medium

$\dfrac{E_{min}}{E_{max}}$ = the inverse standing wave ratio

X_0 = the distance between slab boundary and first minimum in the standing wave pattern

Two such impedance measurements, made with different lengths of sample slab, allow the unknown constants to be calculated. When the sample is known to be nonmagnetic, a single impedance measurement suffices.

Actually measurements are usually made in waveguides to overcome two inherent difficulties with space measurements:

1. The divergence of beams limits sensitivity for loss measurements.

2. Higher order modes introduce uncalculable error except in large sheets of samples.

Common methods of measurement of ϵ^* use a sample resting either against the short-circuited end of a transmission line, or a quarter wave length from it. For these two cases, curves of X_0 and E_{min}/E_{max} were plotted as functions of wave length in the sample. From these graphs the rate of change of measured quantities with ϵ' and $\tan\delta$ can be obtained. With the rate of change known and the experimental error in measuring the probe displacements determined, the per cent error of the measurements can be calculated.

Resonance and standing wave methods are basically the same and can be shown to have identical accuracy for the same per cent error in measuring the incremental quantities.

Measurement of the Electrical Characteristics of Quartz Crystal Units by Use of a Bridged Tee Null Network; *Charles H. Rothauge (The Johns Hopkins University, Baltimore, Md.).*

Specification of quartz crystal units has been made in the past by use of a test oscillator with the scale of activity the rectified grid current. However, it is possible to specify a crystal by use of its equivalent electrical constants. A bridged tee null network has been used to measure the equivalent resistance and the equivalent reactance of a crystal plate.

A tee configuration of capacitance and resistance is used which has a transfer impedance equivalent to a negative resistance and a capacitive reactance. The crystal operating at a frequency between series-resonance and antiresonance can be represented by a resistance in series with an inductive reactance. The tee bridged with a crystal will form a null transmission network, and the electrical constants of the crystal may be measured at its operating frequency.

This measuring circuit has the advantages that shielding is relatively simple (both the source and the detector have a common grounded terminal), and that corrections for all stray capacitances that affect the measurements may be included in the calibration of the capacitors of the tee. Disadvantages of the method are that coupling between the source and detector will affect balance conditions; also a variable resistor is required.

Buffer amplifiers of conventional design adequately alleviate the difficulty of coupling, and a variable resistance box was constructed that maintains its values of resistance within five per cent of its d-c values up to frequencies of seven megacycles per second with almost constant capacitance to its shield. This box gives values of resistance of 0 to 15,210 ohms in steps of ten ohms with a capacitance to its shield of 23.5±0.3 micro-microfarads for all values of resistance. The box was constructed in such a manner that at all times three resistance elements are in series. Thus with reasonable care in its construction capacitance to the shield is constant. The individual resistance elements are deposited carbon resistors which have relatively small reactance and constant effective resistance.

Measurements have been made on four series of crystals at frequencies ranging from 4.5 megacycles per second to about 7.5 megacycles per second. Values of equivalent reactance were determined from about 200 ohms to 750 ohms, and values of equivalent resistance varied from 10 ohms to 35 ohms.

The precision of these measurements is estimated to be ±0.3 per cent for the determination of the equivalent reactance and ±2.3 per cent for equivalent resistance.

Measurement of Artificial Dielectrics for Microwaves; *Winston E. Kock (Bell Telephone Laboratories, Murray Hill, N. J.).*

One of the important uses of dielectrics in high-frequency radio work is in the field of microwave lenses. In many applications, lenses have certain advantages over other microwave antennas, and a satisfactory dielectric or refracting material is thus desirable. Natural dielectrics, such as polystyrene, have the disadvantage of great weight, and to circumvent this difficulty, several types of lightweight artificial dielectrics have been developed at the Bell Laboratories.

The first refracting medium was made of thin conducting plates which acted as waveguides and caused radio waves passing through them to assume a higher phase velocity. The index of refraction was thus less than unity and a concave shape was necessary to produce a converging lens. Such lenses, ten feet square, are now in use in the Bell System microwave radio relay link between New York and Boston.

These first lenses, however, because of their waveguide properties, possessed bandwidth limitations, and the desirability of antennas

capable of accommodating wider bands for use in the New York-Chicago radio relay route led to the development of a broad-band lightweight artificial dielectric. These "metallic" dielectrics comprised arrays of conducting elements such as spheres, disks, or strips, and the polarization of the conductors simulated the polarization and hence the refractive power of a true dielectric for wavelengths long compared to the size and spacing of the elements[1].

Early theory does not yield refractive indexes which agree well with experiment for practically desirable values of 1.5 or 1.6, so that the properties of the dielectrics must be investigated experimentally.

One such method is similar to the waveguide technique for measuring the properties of true dielectrics. Metal strips (or dielectric strips upon which squares or disks of conducting coating have been deposited) are inserted into a polystyrene foam support. From the position of the standing wave minimum and the magnitude of the standing wave, the dielectric constant and the loss tangent can be deduced.

A second method for evaluating the refractive index is to measure the optimum focal length of a complete lens; this may be done either by phase measurements across the aperture of the antenna[2], or by an examination of the directional patterns for various focal lengths. The optimum focal length yields the flattest phase fronts and the deepest nulls in the directional pattern. Upon observing directional patterns of a 7-centimeter microwave lens of 6-foot aperture with the feed placed at various distances behind the lens, the depth of the nulls shows the true focal length to be about 62 inches. Since a one inch axial departure of the feed horn from the true focus on this lens causes the phase front to deviate from a plane by only $\pm 1/60$ of a wave length, it can be concluded that this method is quite sensitive. A one inch change in the observed optimum focal length in this lens will change the evaluated index of refraction (which in this case is approximately 1.5) by 0.005.

One interesting observation is that the microwave properties of certain of the foregoing arrays can be inferred from acoustic measurements. The various obstacle array lenses were found to focus sound waves as well as microwaves so that measurement of the refractive index of certain structures, such as the strip array, could be made by the simpler acoustic measurements. Since 3.45-centimeter sound waves have a frequency of about 10,000 cycles, a continuous variation of wave length from one centimeter or less up to 10 or 20 is readily available acoustically.

A 6-inch square strip prism of open construction which was originally made for 3-centimeter microwave experiments was tested acoustically, and, from the angle of deviation which it imparted to the beam of a 6-inch horn, its refractive index could be ascertained for various frequencies. Such a curve was plotted. By spot checks, it was ascertained that, for like wave lengths, the measured acoustic index of refraction agreed with the measured microwave index.

REFERENCES

1. Metallic Delay Lenses, **W. E. Kock.** *Bell System Technical Journal* (New York, N. Y.), volume 27, 1948, page 58.

2. Microwave Antenna Measurements, **C. C. Cutler, A. P. King, W. E. Kock.** *Proceedings*, Institute of Radio Engineers (New York, N. Y.), volume 35, 1947, page 1468.

Microwave Noise Sources; *I. Mirman, J. H. Vogelman* (*Watson Laboratories, Red Bank, N. J.*), *R. H. George* (*Purdue University, Lafayette, Ind.*).

Pulsed-type noise generators are of either the coaxial or flat disk radial line type and utilize the discharge of a charged circuit as the source of noise. Units have a resonant frequency that is selected to give a desired noise spectrum output of constant amplitude over a frequency band up to at least 75 per cent or more of the resonant frequency. The output characteristic curve of the pulse-type generator resembles that of a low pass filter and proper selection of the peaking frequencies during design can be used to obtain any desired response characteristic. The coaxial noise generator consists of an open-ended coaxial line charged through a high resistance and discharged by short-circuiting inner and outer conductors. The contact between the inner and outer conductors is made by means of a driven inner conductor contacting a fixed flat point on the center conductor of the coupling transmission line which is at the same d-c potential as the outer conductor. The very short switching time produces a pulse of very narrow width and very sharp rise time with the resulting high-frequency components. Design relations predict possibility of reaching 375,000 megacycles per second utilizing flat disk contacts.

The mercury droplet noise generators produce noise by discharging a charged mercury droplet on contact with a mercury pool acting as a ground plane. The mercury droplet acts as a spherical quarter-wave antenna and radiates energy on discharge. Random or pulse-type noise is generated by controlling the type of flow and size of the droplets. Two basic types of charging the mercury droplets are the induction and the self-charging type. The induction type of charging involves the dropping of small mercury droplets formed by flowing mercury through small parts. The droplet falls through an intense electric field at high velocity, becomes charged, and is discharged on contact with the ground of mercury. In the self-charging type, mercury droplets are charged as a result of the impact of a high-velocity droplet on a piece of dielectric. On impact, the drop flattens, gathers charge, regains its normal spherical shape due to surface tension and rolls off the dielectric fully charged, and on contact with the ground plane is discharged. Frequency range in coaxial units is in order of audio to 5,000 megacycles per second, and for waveguide-type units exceeding 50,000 megacycles per second are achieved.

The Transmission-Line Method of Testing Loop Receivers; *C. E. Kilgour* (*Crosley Division, Avco Manufacturing Corporation, Cincinnati, Ohio*).

To meet the need for a method of measuring over-all sensitivity of radio receivers having large loop antennas, especially standard broadcast receivers mounted in console cabinets where the loop is as large as the cabinet back, the standards committee of the Institute of Radio Engineers has recently adopted "The Transmission Line Method." Quoting the standard: "The method consists of stretching a . . . wire . . . between two insulators at a uniform distance below the roof (the inner shield) of the screen room and parallel to the longest dimension of the room." One end of the line is connected to a signal generator and the other to the screen of the room through a resistor equal to its characteristic impedance.

Assuming a room with dimensions a very small part of a wave length and with walls which are perfect reflectors, the end walls serve to extend the length of the line so that the field in the absence of the floor, ceiling and side walls has cylindrical co-ordinates and is inversely proportional to the distance from the line. A consideration of all the possible reflections from these last four surfaces yields a summation of a double infinity of terms. If the width of the booth is greater than the distance from line to floor, all terms due to side walls may be neglected leaving only those due to ceiling and floor. The first eight of this set follow:

$$E=60\,I\left[\frac{1}{x}-\frac{1}{2c+x}+\frac{1}{2f-x}-\frac{1}{2f-x+2c}+\frac{1}{2f+x+2c}-\frac{1}{2f+x+4c}+\frac{1}{4f-x+2c}-\frac{1}{4f-x+4c}+\ldots\right]$$

E is the field strength in volts per meter, I the current in the line in amperes, f the distance from line to floor, c the distance from line to ceiling, and x the distance to any point directly below the line. The terms may be combined:

$$E=60\,I\left[\frac{2c}{x(2c+x)}+\frac{2c}{(2f-x)(2f-x+2c)}+\frac{2c}{(2f+x+2c)(2f+x+4c)}+\frac{2c}{(4f-x+2c)(4f-x+4c)}+\ldots\right]$$

At floor level $x=f$

$$E=60\,I\left[\frac{4c}{f(f+2c)}+\frac{4c}{(3f+2c)(3f+4c)}+\ldots\right]\cong 240\,I\,\frac{c}{f(f+2c)}\;1+\frac{1}{9}+\frac{1}{25}+\frac{1}{49}+\ldots$$

This last has been extended to the equivalent of 16 terms of the original series. The use of a large number of terms is probably not justified because of phase shift and reflection loss.

The committee recommends the use of four terms of the original series, with integration of the field over a large loop to obtain the average field strength.

The committee also recommends that the line be terminated in its characteristic impedance. However, it would appear that since the line is a very small part of a wave length, standing waves are no problem and it is sufficient that the loading resistor be large enough to swamp out the inductance of the line. It is necessary only that the current through the line be calculated readily from the voltage reading of the signal generator. The loading resistor may be placed between the generator and the line with the far end of the line connected directly to the screen, thus reducing the unwanted field due to line potential. With some signal generators, it is possible to place the final shunt resistor of the output attenuator in series with the transmission line, and tune out its inductance with a series capacitor thus securing maximum field strength.

INSTITUTE ACTIVITIES

Our Technical Committees—The Electrical Engineer and His Technical Contributions

—*A Message From the President*

The technical contributions of the electrical engineer never cease—they have advanced electricity into every available avenue for the service of man, which has been characterized as more revolutionary for the well-being of the people of the world than any other material thing in recorded history. And so it is in our Institute; the base is ever broadening, ever expanding.

In our Institute year 1939–40, there were 19 technical activity committees actively at work in the technical aspects of the contributions of the electrical engineer. In this year 1948–49, the number of technical activity committees is 35, almost double that of nine years ago.

In the year ending April 30, 1940, our Institute held two general meetings and three District meetings, with an attendance of 3,548. There were 177 papers presented, 151 of which were preserved in our *TRANSACTIONS* for the benefit of all, which is our great contribution.

In the year ending April 30, 1948, our Institute held four general meetings and three District meetings, with an attendance of 8,095. There were 540 papers, 233 of which were preserved in our *TRANSACTIONS* for the benefit of all. The remainder were 214 conference papers and 30 papers, advance copies only, not intended for publication in the *TRANSACTIONS* of AIEE.

We are not keeping pace with our *TRANSACTIONS* papers. The *TRANSACTIONS* papers are one of the great strengths of our Institute in that here is preserved for all time a history of the new developments and advances in electrical engineering. Herein is recorded the new advances for the student that he may know intimately of what is the latest in the electrical engineering field of his choice. Here is recorded the new developments that every teacher may advance in his teaching with the technical progress of the times. Here is recorded the contributions of the electrical engineer for all of his fellow engineers to see, and from which inspiration is gained for new ideas to come. The eyes of the electrical engineering world are on our *TRANSACTIONS* papers; it is our responsibility that they be preserved in their entirety as recommended by our technical committees and our technical program committee. And it is essential that they be preprinted well prior to their presentation for full and vigorous discussion.

Our winter general meeting technical program in New York, N. Y., January 31 to February 4, 1949, scheduled papers as follows:

TRANSACTIONS	74
Advance copies only	16
Conference	137

The cost to our Institute of these papers is estimated to be about $21,125. If the conference papers were *TRANSACTIONS* papers the cost to our Institute is estimated to be about $40,142 additional; this includes the cost of the papers and the cost of additional headquarters staff to process them. Many wish our conference papers might be made available to all. The foregoing figures give an idea of the increased cost to so provide for just this one meeting.

Your president was this year a leader in providing for a balanced budget. This prevented us from having the increase in *TRANSACTIONS* papers which some visualize should be. I fully recognize the seriousness of any curtailment of our technical activities. To provide for further expansion of our *TRANSACTIONS* papers there will have to be a dues increase.

If this must come about due to our bursting seams of papers worthy of being made available to our fellow engineers, then I trust that each member of our Institute will recognize with pride his contribution to this fundamental strength of our Institute and will be eager and willing to contribute his share. This is working together at our best.

South West District Meeting to Feature Engineers' Contribution to Southwest

The 1949 AIEE South West District meeting will be held in Dallas, Tex., April 19–21, with headquarters in the Baker Hotel.

Dallas—the city with the charm of yesterday and the spirit of tomorrow—is one of the youngest and most cosmopolitan of America's big cities. Big "D," as Dallas is known affectionately by its Southwestern neighbors, is a man-made city, the product of aggressive citizenship and engineering ingenuity. Today, Dallas, with more than 500,000 population, centers a Southwest region with $17^1/_2$ million consumers, with a net effective buying income of $15^1/_2$ billion dollars. AIEE visitors to the South West District meeting will have the opportunity of seeing one of the fastest growing cities in the nation.

The general theme of the meeting will be, "What Electrical Engineers Are Doing to Meet the Needs of the Growing Southwest." The general sessions and technical programs have been developed around this theme. Nationally known speakers will discuss the contributions made by electrical utilities, communication companies, heavy industry, manufacturing, and education in the general sessions. Technical sessions will present papers on communication, power, transmission and distribution, and nucleonics.

ENTERTAINMENT

An entertainment program has been arranged for both men and women.

On Tuesday evening at 6 p.m. there will be a stag smoker and buffet dinner in the Peacock Terrace of the Baker Hotel, while on Wednesday evening at 7 p.m. there will be an informal banquet in the Crystal Ballroom of the Baker Hotel, followed by dancing.

The Metropolitan Grand Opera will be in Dallas on April 22, 23, and 24, with performances of Othello, Mignon, The Marriage of Figaro, and Aida. Those desiring to remain in Dallas for the opera should write immediately directly to the Dallas Grand Opera Association so that they may be placed on the mailing list to receive literature, which includes order blanks for tickets to the aforementioned performances.

WOMEN'S ENTERTAINMENT

Tuesday will be "Get-Acquainted Day" and a Hostess Parlor will be available in the Baker Hotel. The women are cordially invited to use the facilities of the parlor and hostesses will be available to help arrange sight-seeing, shopping, or other activities.

Tuesday evening the women will be entertained in the Century Room of the Adolphus Hotel. Dinner will be served and followed by an unusual and attractive ice show (this

New Handley 45,000-kw steam-electric station of the Texas Electric Service Company, to be inspected during the AIEE South West District meeting (general view from southwest)

event will take place at the same time as the stag smoker).

On Wednesday there will be a luncheon and style show in the Mural Room of the Baker Hotel. This style show will be presented by the world famous Neiman-Marcus Store.

Thursday morning at 10 a.m. there will be a conducted tour of some of Dallas' exclusive residential areas and beautiful flower gardens. At this time of year flowers are the most beautiful in this section, and visitors will have an opportunity of seeing them in full bloom.

INSPECTION TRIPS

Inspection trips have been arranged for Tuesday, Wednesday, and Thursday afternoons. These trips will include visits to the following places of interest:

Aircraft: Temco and Chance Vought plants in Dallas and the Consolidated Vultee Plant near Fort Worth, where the giant *B-36's* are built

Power plants: Dallas Power and Light Company's Mountain Creek plant and the Texas Electric Service Company's new Handley plant

Television station: *WBAP's* new $1,500,000 station at Fort Worth

Laboratories: Magnolia Petroleum Company and Humble Oil and Refining Company laboratories near Dallas

Industrial plants: Small parties may be organized to visit many of the industrial plants in the vicinity of Dallas

SPORTS

For those who so desire, arrangements can be made for golf or tennis at any one of the many beautiful country clubs in the vicinity of Dallas. Professional Texas League baseball games can be seen in either Dallas or Fort Worth.

HOTEL ACCOMMODATIONS

Two of Dallas' most famous hotels, the Baker and Adolphus, have set aside blocks of rooms for attending visitors. Members should make their plans early. All requests for hotel reservations should be sent directly to the hotel. A copy of the letter to the hotel also should be sent to George A. Smith, Jr., P.O. Box 299, Dallas 1, Tex. Because of the unusual demand for accommodations during the opera season, rooms must be vacated by 6 p.m. on Thursday, April 21, unless specific arrangements are made to the contrary.

Special low cost accommodations at the hotels will be arranged for student visitors to the meeting.

COMMITTEES

The chairmen of the committees making arrangements for the South West District meteing are as follows:

Elgin B. Robertson, *chairman;* P. G. Wallace, *vice-chairman;* C. Walker Mier, *vice-chairman*

Subcommittee chairmen are

O. S. Hockaday, *meetings and papers;* George A. Smith, Jr., *hotel and reservations;* C. M. Mackey, *transportation and inspection trips;* A. L. Jones, Jr., *entertainment;* Harry R. Pearson, *publicity;* R. L. Biesele, Jr., *Student activities;* C. C. Musgrove, *finance;* Mrs. E. N. Jolliff, *ladies entertainment*

Tape Recording Demonstrated for California University Students

The talents of Bing Crosby, the NBC Symphony Orchestra, and a university student pianist were combined to introduce high fidelity magnetic tape recording to the University of California Society of Electrical Engineers when the combined Student Branches of the AIEE and the Institute of Radio Engineers held their December general meeting, December 15, 1948.

Approximately 300 students, guests, and members of the San Francisco, Calif., chapters of the parent engineering societies saw Howard Lindsay, Ampex Corporation engineer, demonstrate a studio-type magnetic tape recorder declared to have a flat response over the entire audio frequency range.

Coincident with the demonstration, graduate student Robert Smith unveiled a newly developed high-frequency tweeter featuring a flat response from 5,000 to 20,000 cycles. The tweeter, designed by Smith and Walter Selstead, chief engineer for frequency modulation radio station *KSFH*, was incor-

Future AIEE Meetings

AIEE Conference on Industrial Applications of Electron Tubes
Statler Hotel, Buffalo, N. Y.
April 11–12, 1949

South West District Meeting
Baker Hotel, Dallas, Tex.
April 19–21, 1949
(*Final date for submitting papers—closed*)

AIEE Conference on Rubber and Plastics Industries
Portage Hotel, Akron, Ohio
April 26, 1949

AIEE Conference on the Textile Industry
Massachusetts Institute of Technology, Cambridge, Mass.
May 3, 1949

AIEE Conference on the Textile Industry
Georgia School of Technology, Atlanta, Ga.
May, 1949

AIEE Conference on Materials Handling
Cleveland, Ohio
April, 1949

Summer General Meeting
New Ocean House, Swampscott, Mass.
June 20–24, 1949
(*Final date for submitting papers—March 22*)

Pacific General Meeting
Fairmont Hotel, San Francisco, Calif.
August 23–26, 1949
(*Final date for submitting papers—May 25*)

Midwest General Meeting
Netherland Plaza Hotel, Cincinnati, Ohio
October 17–21, 1949
(*Final date for submitting papers—July 19*)

Winter General Meeting
New York, N. Y.
January 30–February 3, 1950
(*Final date for submitting papers—November 1*)

porated into a standard-theatre-type high-fidelity loud-speaker system for the demonstration.

As an illustration of the fidelity of the recorder, the audience was subjected to the "A-B test," in which piano music from another building was transmitted alternately through a high-fidelity amplifying system and through the recorder, which is designed to permit instantaneous monitoring. Afterwards, original recordings from the Bing Crosby show and the NBC symphony program were played for the audience.

Electron Tube Conference to Cover Industrial Applications

The AIEE will hold a conference on the industrial application of electron tubes in the Statler Hotel at Buffalo, N. Y., on April 11–12, 1949. This conference will feature papers and frank discussions covering the entire field of electron tubes in industrial applications with regard to the experiences of the users of such equipment, the designers and manufacturers of electronic equipment, and the manufacturers of electron tubes for industrial applications.

Some highlights of the program include: tube applications in the industrial field, a trip to the Westinghouse plant in Buffalo which manufactures a variety of industrial electronic control devices, a résumé of operating experiences by typical industrial users of electron tubes in many varied fields, problems confronting the manufacturers of equipment using tubes, and rating considerations which must be met by the designers of electron tubes for industrial use.

A few of the tentative papers include:

"Electronic D-C Motor Control"

"Electronic Regulation and Regulating Systems"

"Electronic Control of A-C Power"

"Electronic Relaying Devices and Photoelectric Controls"

"The Adequacy and Inadequacy of Present Tube Ratings"

"The Need for Basic Tube Ratings"

"Ratings of Pool Tubes for Control and Rectification"

"Special Ratings for Mercury Vapor and Gas Tubes"

"The Meaning of Phototube Ratings"

The dinner meeting on Monday evening will feature an address on a subject of interest to all engineers and users of tubes. Also, the Monday evening session will cover a discussion of operating experiences by several large users of industrial electron tubes in various industries. This will include service, application, and maintenance considerations of such equipment.

Rubber and Plastics Meeting. An AIEE conference on the rubber and plastics industries will be held on April 26, 1949, in Akron, Ohio. Arrangements have been made by C. R. Reid, chairman of the Akron Section, for the use of the Portage Hotel as headquarters for the meeting. The session will be sponsored by the AIEE subcommittee on rubber and plastics industries, under the chairmanship of K. W. John, which is a subcommittee of the general industry applications committee. A program for the conference is scheduled for publication in the April issue of *ELECTRICAL ENGINEERING.*

Summer General Meeting to Be Held at Swampscott, Mass.

The 1949 AIEE summer general meeting is scheduled to be held at the New Ocean House, Swampscott, Mass., June 20–24. Trips to interesting places along the north shore of Massachusetts are being planned, and the bathing and sports facilities of the hotel, which are considered excellent, will be at the disposal of the members. Special attention is being given to women guests.

One of the features of this meeting will be an inspection trip to the Massachusetts Institute of Technology in nearby Cambridge, Mass. In addition to the large and complete general facilities of the institute, one of the United States' foremost institutions of technical education, the following unusual features of the Massachusetts Institute of Technology will be of great interest to electrical engineers from the various sections of the country:

1. Research laboratory of electronics.
2. Meteorological research.
3. Laboratory for nuclear science and engineering.
4. Gas turbine laboratory.
5. Wright Brothers wind tunnel.
6. Supersonic laboratory.
7. Servomechanisms and control.

This is an outstanding opportunity to see in operation a most important group of our country's scientific research equipment.

The personnel of the summer meeting committee is

E. W. Davis, *general chairman;* M. A. Princi, *vice-chairman;* Ralph E. Muehlig, *secretary-treasurer;* R. G. Porter; F. P. Taugher; R. G. Slauer

Subcommittee chairmen are

A. Lee O'Banion, *registration;* R. G. Conners, *hotels;* J. O'R. Coleman, *meetings and papers;* H. B. McIntyre, *publicity;* J. M. Whittenton, *inspection;* F. S. Bacon, Jr., *hospitality;* G. J. Crowdes, *smoker and banquet;* Chester A. Corney, *finance;* Mrs. Fred Haenssler, *ladies committee;* A. B. Whitehouse, *transportation;* E. W. Boehne, *Student activities*

Official Nominees Announced for 1949 AIEE National Election

James F. Fairman, vice-president, Consolidated Edison Company of New York, Inc., New York, N. Y., was nominated for the AIEE presidency for the year 1949–50 at the meeting of the nominating committee in New York, N. Y., January 31. Others named on the official ticket of candidates for the Institute offices that will become vacant August 1, 1949, are

For Vice-Presidents

C. G. Veinott, manager, induction motor section, industrial motor engineering department, Westinghouse Electric Corporation, Lima, Ohio (Middle Eastern District, number 2)

Walter J. Seeley, chairman, department of electrical engineering, Duke University, Durham, N. C. (Southern District, number 4)

W. C. DuVall, head of electrical engineering department, University of Colorado, Boulder, Colo. (North Central District, number 6)

Ralph A. Hopkins, supervisor, central station and transportation department, Westinghouse Electric Corporation, Los Angeles, Calif. (Pacific District, number 8)

Arthur H. Frampton, general manager, English Electric Company of Canada Limited, St. Catherines, Ontario, Canada (Canada District, number 10)

For Directors

E. W. Davis, chief engineer, Simplex Wire and Cable Company, Cambridge, Mass.

Noel B. Hinson, vice-president and executive engineer, Southern California Edison Company, Los Angeles, Calif.

Herbert J. Scholz, vice-president and chief engineer, Commonwealth and Southern Corporation, Birmingham, Ala.

For Treasurer

W. I. Slichter, professor emeritus, electrical engineering, Columbia University, New York, N. Y.

The nominating committee, in accordance with the constitution and bylaws, consists of 15 members, one selected by the executive committee of each of the ten geographical Districts, and five selected by the board of directors from its own membership.

The constitution and bylaws of the Institute require publication in *ELECTRICAL*

Of interest to visitors to the 1949 AIEE summer general meeting in Swampscott, Mass., will be the Massachusetts Institute of Technology in nearby Cambridge

ENGINEERING of the nominations made by the nominating committee. Provision is made for independent nominations as indicated in the following excerpts from the constitution and bylaws:

Constitution

Section 31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the secretary when and as provided in the bylaws; such petitions for the nomination of vice-presidents shall be signed only by members within the District covered.

Bylaws

Section 22. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with article VI, section 31 (Constitution), must be received by the secretary of the nominating committee not later than March twenty-fifth of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the nominating committee in accordance with article VI of the Constitution and sent by the secretary to all qualified voters during the first week in April of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

BIOGRAPHICAL SKETCHES OF NOMINEES

To enable those Institute members not acquainted personally with the nominees to learn something about their engineering careers and their qualifications for the Institute offices to which they have been nominated, brief biographical sketches are scheduled for inclusion in the "Personal" columns of the April issue.

High-Frequency Measurements Conference Draws Large Attendance in Washington, D.C.

The conference on high-frequency measurements, held in Washington, D. C., January 10–12, 1949, was one of the most successful conferences held thus far. Fifth of the new type of AIEE meetings known as "technical conferences" (*EE, Feb '48, p 189*), it drew an attendance of some 584 high-frequency measurements specialists who heard papers on all phases of this interesting field. The gathering was the first of its kind to be held on a national basis where the topics were devoted solely to the field of high-frequency measurements.

AIEE, the National Bureau of Standards, and the Institute of Radio Engineers jointly sponsored the meeting which featured four technical sessions totaling some 25 technical conference papers. The AIEE group active in this gathering was the AIEE subcommittee on high-frequency measurements, a subcommittee of the AIEE instruments and measurements committee.

Registration for the meeting took place in the Roger Smith Hotel, but the technical sessions were conducted in the auditorium of the new building of the Department of the Interior. Originally it had been planned that the sessions would be held at the National Bureau of Standards, but the facilities there were deemed inadequate for the attendance expected.

The first session was presided over by E. I. Green, Bell Laboratories, New York, N. Y., who is chairman of the AIEE instruments and measurements committee. Six papers were presented, covering various phases of the measurement of frequency. Doctor E. U. Condon, director of the National Bureau of Standards, was to have opened the session with some introductory remarks, but the pressure of immediate work made it impossible for him to attend. However, he did speak at a luncheon held during the second day of the conference.

The six papers presented in this session covered a wide range of topics concerned with the problems of frequency stabilization of microwave oscillators, as well as other factors that have a bearing on the precise measurement of frequency in the microwave range. A highlight of this session was the description of the new National Bureau of Standards "Atomic Clock" which was described by Harold Lyons of the National Bureau of Standards. This recently announced device shows great promise of becoming the world's time standard.

Measurement of power and attenuation was the subject of the second technical session held on Tuesday morning under the chairmanship of F. J. Gaffney, Polytechnic Research and Development Company, Brooklyn, N. Y., who is also chairman of the AIEE subcommittee on high-frequency measurements. The six papers presented covered such subjects as power sources, methods of measurement, and various types of attenuators for use in the microwave range. The third session held on Wednesday included seven papers and was concerned with measurement of impedance. It was presided over by Hugh E. Webber of the Sperry Gyroscope Company, Great Neck, N. Y. The fourth and last session was held on Wednesday afternoon and included six papers on measurement of noise, and antenna measurements. Chairman for this session was H. A. Wheeler, Wheeler Laboratories, Great Neck, N. Y.

On Tuesday at 12:30 p.m. a luncheon was held at the Roger Smith hotel at which F. J. Gaffney, general chairman of the conference, presided. AIEE President Lee addressed the gathering on the importance of measurements. He complimented the various committees responsible for the conference and said that such conferences bring together men who do the work in engineering to exchange ideas on their problems and this makes for progress in the art. Stuart L. Bailey, president of the Institute of Radio Engineers also spoke at this luncheon. He was very pleased with the conference in general, and said that it filled a definite need. However, he hoped that the "lower frequencies" be not neglected by the engineers working in the high-frequency field. His comment was prompted by the fact that most of the papers presented during the conference were concerned with extremely high frequencies. Doctor E. U. Condon, director of the National Bureau of Standards, then addressed the group present. He welcomed the guests to the inspection trips scheduled during the conference. In this regard he spoke for the National Bureau of Standards, the National Research Laboratory, and the Naval Ordnance Laboratory. He also commented on the enormous growth of technical societies in recent years. This great growth made the problem of running suitable technical meetings very difficult. The conference type of meeting, he felt, was a possible solution to the difficulty of running a large meeting in which many parallel sessions were conducted at the same time. It was fortunate that the committee was able to secure the facilities of the Department of the Interior auditorium for this gathering rather than the auditorium at the National Bureau of Standards which definitely would not have been large enough to accommodate all the guests present.

Inspection trips to three government laboratories were also part of the conference on high-frequency measurements. A tour of the National Bureau of Standards was arranged prior to the first session of the conference on Monday morning. On Tuesday following the luncheon, trips were scheduled to the Naval Research Laboratory, National Bureau of Standards, and the Naval Ordnance Laboratory. These tours were well attended by guests of the conference and afforded them an opportunity to see the work of the government laboratories in various fields with special emphasis on high-frequency measurements. The inspection trips were scheduled so as not to interfere with the technical sessions. This procedure enabled every one to go on one of the trips.

The great success of the conference on high-frequency measurements as well as its smooth operation were largely due to the efforts of the various people who served on the conference committees. These included the following members of the AIEE subcommittee on high-frequency measurements:

F. J. Gaffney, *chairman;* I. G. Easton, E. F. Felch, F. A. Hamburger, G. B. Hoadley, Harold Lyons, H. R. Meahl, H. E. Webber, H. A. Wheeler

The local arrangements committee included the following personnel:

Doctor Harold Lyons, *chairman*, Hugh Odishaw, William Oncken, Wilbert F. Snyder, Doctor L. C. Van Atta

In addition to those listed, a number of people served on the working committees which handled such activities as registration, luncheon tickets, and inspection trip tickets. These included:

Verna L. Killian, Herbert H. Rosen, Mrs. Theresa Slicer, Charles Bragaw, Henry F. Cogan, Joseph H. Hannigan, Edwin J. Browne, John W. Lowenbach

F. S. Schafer, of the Capitol Transit Company, handled the bus service to the inspection trip points.

Although publication of the complete texts of the papers presented including dis-

Analysis of Registration, Conference on High-Frequency Measurements, Washington, D. C.

District	Members	Nonmembers	Totals
1	24	54	78
*2	71	304	375
3	16	56	72
4	7	28	35
5	4	5	9
6			0
7	0	7	7
8	2	4	6
9			0
10		2	2
Totals	124	460	584

* District in which meeting was held.

cussion is not contemplated for this particular conference, it is hoped that when the next one on high-frequency measurements is conducted, such publication may be possible. The complete list of the papers presented, including authors names as well as their affiliations, appeared in the December issue of *ELECTRICAL ENGINEERING* (*EE, Dec. '48, page 1207*).

Brief authors' digests of most of the papers presented at this meeting appear in this issue (*pages 251–7*).

Penn State Students Honor Retiring Professor Doggett

The AIEE Student Branch of Pennsylvania State College, State College, Pa., held a testimonial dinner, January 20, 1949, for Professor Leonard A. Doggett of the electrical engineering faculty, who is retiring after 26 years at that school. Held at the Nittany Lion Inn, the dinner was attended by 144 electrical engineering students and faculty and their wives. (Full details of Professor Doggett's retirement will be found in this month's "Personal Notes," page 268.)

C. H. Grace, Student Branch chairman, acted as toastmaster for the program which included humorous skits concerning Professor Doggett's relations with the student body as teacher and counselor and several tributes by his fellow faculty members. Professor Doggett was presented with a gift from the local chapter of Eta Kappa Nu, and also received an engraved Penn State Seal Key from the AIEE Student Branch. He concluded the program with a brief talk in which he thanked the assemblage for their kindnesses.

Winter Meeting's 226 Papers Comprise Largest Program in Institute History

When plans were being made for the 1949 winter general meeting in New York, N. Y., announcements went forth that the technical committees were making a special effort to assemble a technical program which would cover the electrical field completely. The results of these efforts were demonstrated graphically at the Hotel Statler during the week of January 31–February 4, when this year's meeting program, featuring a total of 55 technical sessions and conferences covering some 226 papers, officially went on record as the largest technical program in the history of the Institute. The program was organized under four general topics: communication and science, power, industry, and general applications.

The 1949 winter general meeting also marked two other firsts. With headquarters at the Hotel Statler (the former Pennsylvania), this was the first time that a winter meeting in New York has been held outside of the Engineering Societies Building at 33 West 39th Street. That the choice was a happy one was attested to by the 2,896 AIEE members and guests attending, who found the arrangement most convenient both for technical and social activities, as the majority of the visitors were staying at the Statler or neighboring hotels in the Pennsylvania Station area. In addition, in accordance with the policy recently set up by the board of directors as an attempt to help make these meetings self-supporting, this was the first time that a registration fee has been charged at a winter general meeting. The amount was nominal; $3 for members and $5 for nonmembers, while Student Members and the immediate families of members were admitted without charge.

SESSIONS

With the unprecedented scope of subject matter offered by this year's winter meeting program, almost every topic of professional interest to the electrical engineer was covered. Sessions ranged from applied mathematics to industrial control, and included such diverse items as electrical tests on dielectrics in the field, electrostatic precipitation, industry's active part in education, and control and protection of household equipment.

On Thursday, February 3, the AIEE board of directors met in all-day session at Institute headquarters; while during the course of the week some 79 meetings of AIEE technical and administrative committees were held, either in the Engineering Societies Building or at the Hotel Statler.

Highlights of some of the sessions are reported in the following pages; other sessions will be reported in the April issue.

EDISON MEDAL PRESENTATION

At a general session on Wednesday, February 2, the 1948 Edison Medal was presented to Morris E. Leeds of the Leeds and Northrup Company, Philadelphia, Pa., "for his contributions to industry through development and production of electrical precision measuring devices and controls." Mr. Leeds is thus the 38th outstanding electrical engineer to win this coveted medal which is awarded annually in recognition of "meritorious achievement in electrical science."

I. Melville Stein, who is with the Leeds and Northrup Company as vice-president and director of research, presented a biographical sketch recounting the achievements of the medalist, while a history of the Edison Medal itself was given by A. E. Knowlton, senior associate editor of *Electrical World*, McGraw-Hill Publishing Company, New York, N. Y.

The general session also featured addresses by AIEE President Everett S. Lee and Charles E. Wilson, president of the General Electric Company. Full texts of the Edison Medal addresses, as well as those given by President Lee and Mr. Wilson, appear elsewhere in this issue of *ELECTRICAL ENGINEERING*.

ENTERTAINMENT

One of the most popular social events of the winter meeting, as usual, was the smoker, which was held this year on Thursday night, February 3, at the Hotel Commodore, with Tuesday' evening's dinner-dance at the Hotel Statler a close second in popularity. Through the offices of the theater ticket committee, members also were able to obtain tickets to a number of leading Broadway shows.

Women attending the meeting enjoyed a very active week in New York, beginning with a "get-acquainted" at Hotel Statler women's headquarters on Monday morning. On Tuesday they visited the United Nations and on Wednesday they were given a tea and fashion show at the Pierre, tendered by the Westinghouse Electric Corporation. The main event on Thursday was a dinner and bridge at the Engineering Women's Club. Alternating as hostesses at women's headquarters in the Statler during the meeting were Mrs. Dixon, Mrs. Talley, Mrs. Callahan Mrs. Buckley, Mrs. Minasian, Mrs. Lowell, Mrs. Purnell, Mrs. Banghart, Mrs. Sutherand, and Mrs. Braymer.

INSPECTION TRIPS

One of the most interesting features of Institute meetings always is the schedule of inspection trips which is arranged to carry out, as far as possible the subject matter of the various technical sessions; and this year proved no exception. A gratifying number of members took advantage of the opportunity to visit an unusual modern communications research laboratory, the Federal Telecommunications Laboratories; the Jamaica substation of the Consolidated Edison Company, Inc., which is a new substation having a double-deck arrangement of 138-kv and 27-kv busses and metalclad isolated-phase 27-kv equipment installation; the new and modern material laboratory at the New York Naval Shipyard, Brooklyn, N. Y.; the meter division of the Westinghouse Electric Corporation at Newark, N. J.; and Columbia University's new 400,000,000-volt synchrocyclotron, which is now in the final stages of completion and testing.

DIGESTS OF MEETING PAPERS

Short authors' digests of most of the conference papers presented during the winter general meeting in New York are scheduled for publication in the April issue. The customary one page digests of the technical program papers will appear in succeeding issues of *ELECTRICAL ENGINEERING*.

Sections Committee Meets During Winter General Meeting

On Tuesday, February 1, an important meeting of the Sections committee, with J. C. Strasbourger presiding, was held at which various aspects of Sections activities were discussed.

In regard to Institute and Section finances, E. P. Yerkes, chairman of the finance committee, explained that expenditures were running about true to form within the balanced budget prepared last fall. He stated that the Sections committee budget for the current year was 30 per cent in excess of what was spent two years ago. The next speaker, D. A. Quarles, chairman of a special committee on Institute dues, expressed belief that expenditures had been cut back about as far as possible. In his opinion, it would be wise to put through a constitutional amendment so that the dues question would be in the bylaws, which would permit the board of directors to establish a sound vigorous program.

In commenting on the matter of finances and dues, President Lee felt confident that engineering ingenuity would solve the problem. If the same ability is applied to the operation of the Sections, as in solving engineering problems, everything would come out all right. He explained that Quarles would attack the problem by forecasting what the Institute would do in the next five years. The Sections finance and publication committees should do likewise. Without increasing the income the Institute would go along as it has, which would be unsatisfactory. If the true picture is obtained and properly presented by Section officers, President Lee was confident that the plan would be acceptable to the members.

The topic of Institute and Section publicity was discussed by R. K. Honaman, chairman of the newly-created committee on public relations. The committee would like to assist with public relations in the Sections, and will compile a kit of suggestions, if the Sections will advise them of their needs.

C. S. Purnell outlined what had been done in the revision of the booklet, "The Electrical Engineer." The Sections committee went on record as approving the revised manuscript for submission to the Institute for publication.

Among other items of business, Fisher Black submitted an interim revision of the rules on "Prizes for Technical Papers," which was an attempt to simplify the rules as written and thus to provide incentive for authors to prepare papers.

Secretary H. H. Henline congratulated the Sections on the splendid work being done. He had noted very rapid progress in the number of transfers to higher grades, and urged that the Sections keep their membership lists up to date. In reference to reporting meetings he explained that as the fiscal year ended on April 30, the receipt of reports in the summer made matters difficult and that Sections were not required to report educational courses.

Membership Committee Meets in Open Session

An open session of the AIEE membership committee was held on Wednesday, February 1, with Chairman Fischer Black presiding, and the following subjects were presented and discussed:

1. "Student Memberships as a Means of Increasing Institute Membership," J. C. Woods, vice-chairman, Membership committee
2. "Program for Soliciting Associate Applications from Student Members," F. A. Norris, secretary, membership committee
3. "Problems of Membership Committees and Suggested Solutions," J. A. Duncan, Jr., member-at-large
4. "A Planned Membership Committee Program," Fischer Black, chairman, membership committee
5. "Our Membership Objective," E. S. Lee, president, AIEE

The usefulness of membership activities was discussed by President Lee. He suggested that the membership committee of each Section should watch closely to see that the activities of the Sections conform to the interest of all of the membership as well as to any prospective members and that the committee call attention to any deficiency.

Attention was called to the wide variance in the interpretation by Student Branches of the time of eligibility for Student membership by Vice-Chairman Woods. He cited that some Branches consider all electrical engineering students eligible while others await the time when the student is in his sophomore, junior, or senior year, to encourage an application for Student membership. It was felt that there should be a more uniform attitude toward this important activity and a joint committee might be able to make useful recommendations. A motion was carried to appoint a joint committee to serve with the committee on Student Branches to study the general subject of Student membership as it is handled in each of the Institute Branches.

A motion also was adopted to appoint a special committee to recommend new format for the membership booklet.

In addition to those on the program, the meeting was attended by three other members of the board of directors, Tomlinson Fort, past chairman of the membership committee, J. C. Strasbourger, chairman of the Sections committee, and about ten members of the committee itself serving either as vice-chairmen or members-at-large and an equal number of chairmen of Institute Sections. A general review of membership activities was given by Chairman Black who expressed appreciation to those present for their very helpful discussions.

Eta Kappa Nu Recognition Awards Presented at Winter Meeting Banquet

Eta Kappa Nu (H K N), national honorary electrical engineering society, presented its Recognition Award to Abe M. Zarem, Stanford Research Institute, Los Angeles, Calif., for being "the most outstanding young electrical engineer of 1948," at a banquet held at the Henry Hudson Hotel on Monday evening during the AIEE winter general meeting. This was the 13th presentation of such an award by the society. The award was established by Eta Kappa Nu in 1936 to recognize meritorious service in the interest of their fellowmen on the part of young electrical engineers, not only for their technical ability and accomplishments already achieved, but also for their interest in cultural and civic advancement and their promise for future developments.

In addition to the presentation of the recognition award to A. M. Zarem, who is manager and chairman of physics research for the Stanford Research Institute, Honorable Mention Awards were presented to J. W. Forrester, associate director of the servomechanisms laboratory, Massachusetts Institute of Technology, Cambridge, Mass., and to Milton E. Mohr, member of the technical staff, Bell Telephone Laboratories, New York, N. Y.

The program was opened with a welcome address by Thomas W. Williams, national Eta Kappa Nu president who introduced the toastmaster, Roger I. Wilkinson, Bell Telephone Laboratories, New York, N. Y.

AIEE President Lee then addressed the gathering, his subject being "The Electrical Engineer—Superlative Achievement," in which he praised the achievements of the young engineers who were receiving these awards. In his remarks he cited the many contributions that electrical engineers made to better living and indicated the necessity for technical men to broaden their field of interest to include social activities of a community and humanitarian type.

Professor Harold L. Hazen of the Massachusetts Institute of Technology then introduced J. W. Forrester, who was presented his Honorable Mention Award. James W. McRea of the Bell Telephone Laboratories similarly introduced Milton E. Mohr who was presented with his award. Jesse E. Hobson, director of the Stanford Research Institute, then introduced Abe M. Zarem, who spoke on "Research: Our Most Precious Natural Resource." In his talk Zarem indicated there were two types of research: applied research and basic research. In the former the investigator pushes back the frontiers of knowledge and lays the groundwork for the latter type of research in which men are able to apply the fruits of the basic knowledge uncovered. Both fields of endeavor constitute our most valuable natural resource and should be encouraged accordingly.

J. Earnshaw Murdoch, Northwestern Bell Telephone Company, who is one of the members of the jury of award, congratulated the recipients on their achievements. Speaking for himself, he pointed out that Eta Kappa Nu well might consider an award that could be presented to electrical engineers working in the teaching profession, design, and operating phases of electrical engineering. Virtually all of the winners of the current and past awards were people who were engaged in research.

Delta Chapter of Eta Kappa Nu (Illinois Institute of Technology) sent their president, Edward F. Koncel, Jr., to present congratulations to Mr. Zarem in person.

Doctor Richard W. Porter, General Electric Company, who is responsible for the development of new and improved rockets for the Army and for the technical supervision of the assembly and launching of *V-2* rockets at White Sands, N. Mex., presented an unusually interesting lecture on the subject of rockets. Musical entertainment was supplied by the Murray Hill male quartet of the Bell Telephone Laboratories.

Biographical sketches on A. M. Zarem, J. W. Forrester, and M. E. Mohr have been published in *ELECTRICAL ENGINEERING* (*EE, Feb '49, pp 175–6*). A list of the previous award winners also has been published (*EE, Dec '48, p 1224*).

Television Papers Featured at Session on Broadcasting

Home radio receivers and broadcasting were discussed at one of the opening technical sessions on January 31. R. E. Shelby of the National Broadcasting Company, New York, N. Y., presided.

"Brightness and Contrast in Television" was the subject of a paper by P. C. Goldmark of the Columbia Broadcasting System, Inc.,

Morris E. Leeds, recipient of the 1948 Edison Medal, receives congratulations from his fellow speakers at the Edison Medal ceremonies on Wednesday of the 1949 winter general meeting. Left to right are AIEE President Everett S. Lee; Charles E. Wilson, president of the General Electric Company; Doctor Leeds; and A. E. Knowlton, chairman of the Edison Medal committee

New York, N. Y. For better video images in television, a greater contrast range is more important than mere brilliance. A contrast range of 30 to one is adequate. Tests show that increased contrast assists the eye to see fine detail. Likewise, experiments with visual acuity and with contrast recognition show that both reach their optimum for a given brightness when the surrounding illumination is about the same as the locally illuminated area. Slides were shown to illustrate changes in contrast and brightness. Several questions were raised regarding brightness and contrast especially in reference to eye strain. The fact was brought out that more than 20 foot-lamberts is not necessary on the screen provided contrast is maintained. The reduction of intensity by filters was discussed.

"Development of Large Screen Meta Kinescope for Television" by H. P. Steier of the Radio Corporation of America covered the new $16^1/_2$-inch receiving tube developed during 1948 for an ever popular demand for a lower cost tube. It is especially adaptable to mass production. Designed for smaller cabinets it has a minimum weight and volume. The three parts: the electron gun, the viewing screen, and the envelopes were described. Control of dimensions can be maintained to 1/10,000 of an inch. Chromium bearing alloys are used for the material because of their good glass-sealing qualities. High-quality plate window glass is used for the screen, which gives a 10 by $13^1/_3$-inch picture. The tilted lens trap is a feature of this tube which is used to separate negative ions and electrons to prevent negative ion bombardment on the screen.

Questions were raised and answered regarding the life tests on the tubes and about the metal to glass seal. It was stated that the strength of the seal was enough to withstand great pressures.

"Input Power Requirements for Television Receivers," a paper by S. C. Spielman of the Philco Corporation, Philadelphia, Pa., was presented by W. P. Boothroyd of the Philco Corporation, Philadelphia, Pa. This paper covered the nature of the electric power load represented by television receivers. Fear of undesirable low power factor loads by power companies have resulted, in one or two instances, in extra penalty charges levied upon television set users. However, on complete television receiver loads that have been checked, a power factor of better than 90 per cent was found. The average power consumption per receiver is approximately 250 watts. Charts were projected which showed the power consumption for a number of television receivers for various picture sizes and as a function of the number of tubes. Questions were raised regarding the input power and line voltage, and about voltage pulsation which has caused some concern. It was reported that more than one million receivers are now in use in the United States.

"Progress Report on Ultrahigh-Frequency Television" was given by T. T. Goldsmith of Allen B. DuMont Laboratories, Inc., Passaic, N. J. The very-high-frequency range covers from 300 to 3,000 megacycles and could handle 69 more black and white television channels between 475 and 900 megacycles. The 12 channels of the very-high-Frequency (30 to 300 megacycles) are not adequate for nation-wide service. In a Washington experiment, tests have been made using this higher range. New transmitter tubes for this range need be developed having a power output of 100 kw. Work is being done on receivers for very-high-frequency reception. High-gain antennas are practical at this frequency. These higher bands are free from interference from elevators and ignitions. Questions were asked regarding the continuous tuning systems, transmission line interference, and intercarrier systems. Either capacity or sliding Leoser wire tuning may be used.

"Large Screen Projection Television" was presented by R. V. Little, Jr., of the Radio Corporation of America. Two basic systems of large-screen television are being studied at the present time. One is direct projection in which the image is projected by an optical system onto the screen, and the other is an intermediate film system in which the image is photographed on 16-millimeter film, processed, and then projected onto the screen. This latter process takes less than one minute to complete. Both systems have been received very favorably by audiences, but improvements to bring high-quality television programs to the theater will continue. At present, the problems of the new systems are concerned with the development of kinescopes capable of handling greater beam currents and operating at higher potentials in an effort to increase the light output, while at the same time develop smaller less-costly reflective optical systems and directional screens with increased light gain. Comparisons were made of the advantages and disadvantages of the direct projection and intermediate film systems.

Radio Communications Systems Provide Interesting Session

A session on radio communications systems was held on January 31 with E. G. Ports of the Federal Telephone and Radio Corporation, Clifton, N. J., presiding.

"A Time Division Multiplexing System" by W. P. Boothroyd and E. M. Creamer, Jr., both of the Philco Corporation, Philadelphia, Pa., was presented by Boothroyd. The new multiplexing system employing time division, as described, features pulse amplitude modulation with a filtering arrangement for minimizing the required transmission bandwidth. Distortion and crosstalk requirements are met over transmission paths including radio relay repeaters. A discussion of channelizing, synchronizing, transmission equipment, and system performance was included. Following the paper, there was a group discussion on the advantages and disadvantages of this system over other systems. Questions of separate pulses versus overlapping pulses, signal-to-noise ratio, and correctors for linear distortion were considered.

"Clampers in Video Transmission," a paper by S. Doba, Jr., and J. W. Ricke of the Bell Telephone Laboratories, Inc., New York, N. Y., covered thd method of cutoff of those frequencies in the lower limit of the frequency range and of their reconstruction at the television receiving end so as to give a satisfactory picture. As described, low-frequency interference may be suppressed by a factor inversely proportional to the frequency of the interference; the factor being large over 30 decibels at 60 cycles. Slides were presented to show the video blanking process, the low-frequency compensation circuit, the series capacitor clamper circuit, and to illustrate the effects of clamping as applied to a signal. A question of time constant was discussed.

A paper entitled "The Transistor, a New Solid State Amplifier," by J. A. Becker and J. M. Shive of Bell Telephone Laboratories, Inc., Murray Hill, N. J., was presented by Becker. A description of the construction and function of this new device, which is capable of performing most of the key jobs now done by the vacuum tube, was given. A number of slides showing its characteristics were presented and discussed. A demonstration was given to show the use of transistors in a circuit.

Another paper on the transistor, "The Coaxial Transistor" by W. E. Kock and R. L. Wallace, Jr., of Bell Telephone Laboratories, Inc., Murray Hill, N. J., was given by Wallace. As described, this transistor has a different construction than earlier models so

as to provide more mechanical stability and to allow shielding to isolate the input and output circuits. Its characteristics are not remarkably different than other types.

Following the presentation of these two papers on transistors, discussions were held regarding conversion efficiency, means for coupling in series, effect of varying the contact pressure, stability with temperature variation, and energy output. Questions were raised and answered on its noise performance and its maximum available gain.

Wide Range of Topics Covered in Basic Sciences Session

Five interesting papers comprised the basic science session which was held on Monday afternoon during the AIEE winter general meeting. The diversity of the topics presented made for an especially interesting session which was presided over by Walther Richter, Allis-Chalmers Manufacturing Company.

The first paper, presented by O. H. Gish, of Carnegie Institution of Washington, was on "Natural Electrical Phenomena of the Atmosphere."

That there exists a marked analogy between the human brain and a computing machine was indicated by W. S. McCulloch, University of Illinois, in his paper "The Brain as a Computing Machine." However, it was pointed out that the human brain is an extremely complex mechanism as compared with a computing machine. He said that a computing machine that could be considered equivalent to the human brain would require a building the size of the Statler Hotel to house it, the electric power of Niagara Falls to run it, and the water of Niagara Falls to cool it.

T. J. Higgins, University of Wisconsin, next presented a paper called "Basic Theory, and Experimental Verification, of the Per Cent Limit Resistance Bridge." The basic equations for this bridge were discussed and three basic bridge circuits were shown. The two final papers presented at this session included "Magnetic Amplifier Analysis Using Ideal Magnetization Curves" by P. M. Kintner, University of Illinois; and "Fundamentals of Contact Resistance," presented by Ragnar Holm, Stackpole Carbon Company.

Fluorescent Lighting Marks a Decade of Progress

The strides made by the fluorescent lighting industry in the past ten years was the subject of the conference on fluorescent lighting held the afternoon of January 31. Three conference papers were presented at the meeting which was presided over by Harris Reinhardt, Sylvania Electric Products, Inc., New York, N. Y.

"Trends in Fluorescent Lamps" were discussed by W. C. Brown, General Electric Lamp division, Nela Park, Cincinnati, Ohio. He accompanied his talk with displays of the various types of fluorescent lights developed by his company, and with numerous slides. After reviewing the history of this type of lighting, Brown went on to show how problems in engineering and manufacturing had been overcome. His summation contained a prophecy for the future development of this new field of illumination.

R. G. Slauer, Sylvania Electric Products, Inc., Salem, Mass., covered the "Economic Considerations" for the fluorescent light industry, including the evaluation of cost in relation to type of installation, expected periods of use, and cleaning and maintenance. He pointed out that incentives to new developments included the need for longer life, instant starting, architectural demands, and brightness control.

Westinghouse Electric Corporation's Marshall Waterman concluded the presentation of papers with his "Trends in Application Techniques." Abundant with slides in color and black-and-white, he showed how installation methods have been developed and improved, and cited the following definite trends in the fluorescent lighting industry: installations now being made in straight lines and geometric patterns; lights are being concealed and are becoming part of the room design; improved quality and wide choice of lamp size, amount of light, and color; increased use of combined fluorescent and incandescent fixtures; planned lighting as a consideration for engineers, architects, and interior and exterior decorators.

The discussion period followed the presentation of all three papers. Brown was asked about ballast failures and lamp explosions. He countered by pointing out that, while they did exist, their occurance was infinitely small in comparison to the number of fixtures in use. The floor raised the point of plastic coating to prevent dangerous shattering, but Brown said that the cost would more than offset any advantages gained by such a plan. Other questions answered by the three speakers included those on the performance of fluorescent lamps at high, humid temperatures, and subfreezing conditions, the hazards from gas vapors released when lamp breaks, the use of the krypton-filled 85-watt lamp in a 100-watt fixture, and applications of various types of starters. C. F. Mitchell, Commonwealth Edison Company, Chicago, Ill., questioned failures caused by fluctuations of voltages from welding operations. Brown's answer admitted that these failures could not be avoided at this stage of lamp development. M. P. Cornelius, International Harvester Company, Chicago, Ill., was concerned with the developments of electric outlets and sockets for use with multiple units. Both Waterman and Brown explained what the industry has done to meet these and other special needs.

Progress Keynotes Session on Land Transportation

The morning session on land transportation, held February 1, showed the developments made in electrical applications to land transportation in the past 25 years. J. C. Aydelott, General Electric Company Erie, Pa., presided over the discussion that followed the reading of the following five technical papers:

49-42, "Application Engineering on Diesel-Electric Locomotives in Railroad Service," by G. T. Bevan, General Electric Company, Schenectady, N. Y.; 49-43, "Twenty-five Years of Progress in the Design of Traction Motors," by M. J. Baldwin, General Electric Company, Erie, Pa.; 49-44, "The Renaissance of Electric Motive Power," by A. H. Candee, Westinghouse Electric Corporation, East Pittsburgh, Pa.; 49-45, "Electric Equipment for Chesapeake and Ohio Railway Company Steam Turbine-Electric Locomotives," by C. A. Atwell and C. E. Baston, Westinghouse Electric Corporation, East Pittsburgh, Pa.; 49-46, "Selenium Rectifiers in Motor Vehicle Power Systems," by G. Ramsey, Fansteel Metallurgical Corporation, North Chicago, Ill.

Engineers and railroad operators argued the use of Diesel-electric locomotives over steam-driven ones. The questions of heating passenger cars by both types, and the operation under emergency conditions, were debated by both sides. Among those taking part in the discussion were: A. G. Oehler, electrical editor, Simmons-Boardman Publishing Company, New York, N. Y.; H. F. Brown, New York, New Haven, and Hartford Railroad, New Haven, Conn.; J. D. Sylvester, Canadian National Railway, Montreal, Quebec, Canada; G. T. Bevan, General Electric Company, Schenectady, N. Y.; T. M. C. Martin, Bonneville Power Administration, Portland, Oreg.

Interest, as evidenced by the amount of discussion, was so great that chairman Aydelott was unable to close the session at the end of the allotted time, and so held the floor open to questions and rebuttals by the audience and the presenters of the papers.

Chemical, Electrochemical, and Electrothermal Session Held

An afternoon conference on chemical, electrochemical, and electrothermal processes was held on Monday, January 31, during the 1949 AIEE winter general meeting.

In the first paper presented, "Power Wiring in Petroleum Refineries," by W. H. Dickinson of the Standard Oil Development Company, data were given indicating the general versatility of cable versus overhead lines in a variety of chemical plants. An opposite view was taken by W. T. O'Meara of the Atlantic Refinery Company who presented the second paper, "Sixty Years of Electrical Distribution in a Petroleum Refinery," by O'Meara and J. A. Britton of the same company.

In the final paper, "The Use of Electric Power in the Transportation of Natural Gas Through the Former Big and Little Big Inch Pipe Lines," presented by W. T. Thagard of the Texas Eastern Transmission Corporation, the engineering considerations in the conversion of the big inch and little big inch oil lines to move approximately 500,000,000 cubic feet of natural gas per day were analyzed. The power consumption will exceed one billion kilowatt-hours in 1949, which is slightly more than the total kilowatt-hours generated in one day in the entire country. With respect to the fires in two pumping stations, the first was the result of a ruptured valve which had nothing to do with the electric equipment. The cause of the second fire has not been determined as yet.

The session was conducted by T. R. Benedict, chairman of the chemical, electrochemical, and electrothermal committee.

Discussion of Watt-hour Meters Featured at Technical Session

With watt-hour meters and miscellaneous instruments as the subject, a technical session was held on Monday morning, January 31, under the chairmanship of W. G. Knickerbocker.

Among the five papers given in this session, A. M. Zarem of the Stanford Research Institute made an outstanding presentation and a significant contribution to high-speed research photography in the paper entitled, "An Electro-optical Shutter for Photographic Purposes." Employing the principle of the Kerr cell with a birefringent material between two plates in the optical axis with a polarizer and analyzer on each side, he explained how photographic speeds of 100 microseconds could be obtained for single pictures. Discussion brought out that the electro-optical system was faster than any known mechanical means by which the film could be moved sufficiently fast for motion pictures.

In another paper, "A New Device for Calibrating Watt-hour Meters," which was presented by H. F. Robison of the Commonwealth Edison Company, an ingenious optical system with a photoelectric cell was employed in combination with an oscilloscope as a null detector for direct comparison of the speed of the teeth in the disk of a standard watt-hour meter with those in the disk of the meter under calibration. Other papers presented dealt with surge protection of watt-hour meters, a new thermal volt-ampere demand meter, and a thermopile type of instrument for measuring low air velocities by F. H. Busch, G. D. Williams, General Electric Company; M. E. Douglass, W. H. Morong, General Electric Company; and C. E. Hastings, Hastings Instrument Company, Inc.; respectively.

In regard to the last-named subject, the accuracy of the instrument at air velocities below 400 feet-per-minute was questioned by E. J. Rutan, consulting engineer, in view of supporting data. The question also was raised with respect to the time lag of the cold junction at low air velocities.

Electronic Instruments Described at Session

On February 1, a session was held on electronic instruments. J. G. Reid, Jr. of the National Bureau of Standards, Washington, D. C., presided.

"A Square-Law Power-Level Recorder" by W. R. Clark and A. J. Williams of Leeds and Northrup Company, Philadelphia, Pa., and W. R. Turner of the Naval Ordnance Laboratory, White Oak, Md., was presented by Clark. This new recorder, as described, is an improved version of a type of recorder which measures alternating voltage, or power-level, on a linear decibel scale by means of a motor-balanced slide-wire attenuator. The detector, which is responsive to the mean square of the instantaneous voltage of its input, was described. A demonstration of the equipment was given to show how it is used in taking a filter characteristic, to show its use as a noise recorder, and to prove that it does have a square-law response. A discussion followed on the chart drive arrangement, the accuracy of the equipment, and the electronic power supply regulator.

A paper on the "Polar Vector Indicator" by A. H. Waynick, E. A. Walker, and P. G. Sulzer, all of The Pennsylvania State College, State College, Pa., was presented by Walker. The indicator, as described, permits the delineation on a cathode-ray tube screen the magnitude and phase angles of as many as three voltages or currents of the same frequency between 15 and 300 cycles per second. The theory of operation and the circuit of the equipment, which has many advantages over former methods in ease and rapidity with which the measurements can be made, were explained. Questions were taken up regarding the response time in the instrument.

"A Regulated, Adjustable Low-Voltage D-C Supply for Electrolysis and Other Use," a paper by M. L. Greenough and W. E. Williams of the National Bureau of Standards, Washington, D. C., was presented by Greenough. This low-vlotage d-c supply uses an audio-frequency carrier current for basis of its operation. A description of the various components was given; a variation in components can produce various characteristics. Graphs were presented to show a schematic diagram and the output characteristics of the unit. A discussion followed on the efficiency of the unit.

A paper which described "A Cathode-Ray Oscillograph With Amplifier and Attenuator Uniform to 30 Megacycles per Second" by R. V. Nathe and C. F. West of the Raytheon Manufacturing Company, Waltham, Mass., was presented by West. This new development recently out of the laboratory was designed originally as a unit for computers. It is described as a wide-band oscillograph which has a high-frequency response that is within a two per cent range in voltage up to 30 megacycles, has less than ten per cent transient overshoot, and has a gain of 100 decibels. Nathe conducted the discussion on various components of the oscillograph, the shunt type of termination, the amplifiers and the gain in buffer stages, and the types of tubes used.

Electronic Digital Computers Considered in Five Papers

A session was held on February 1 to consider electronic digital computer instrumentation. The session was presided over by G. V. Eltgroth of Bendix Aviation Corporation, Baltimore, Md., and S. N. Alexander of National Bureau of Standards, Washington, D. C.

"Application of Electronic Digital Computers in the Public Domain—the Interests of the United States Government" was presented by Alexander, who told of their present useful work and their steadily growing applications in government work. Their use will be seen in the future in the computation of lengthy problems that before either had been disbanded or taken many long hours to solve, in the routine substitution in formulas so as to evaluate statistics, and in government program planning. Many more applications are being explored.

A paper, "Outlook for Electronic Digital Computers—The Scope of the Engineering Involved," was presented by J. W. Forrester of Massachusetts Institute of Technology, Cambridge, Mass. The value of the computer for processing, sorting, and rearranging information, with special attention to the outlook for computer and to the enginering problems involves were considered. The fact was introduced that, at the present time, much effort is being devoted to component research, while the idea of systems engineering or the integration of computer components into equipment must be recognized. Greater study must be applied to co-ordination of computers with communications systems and automatic control devices.

"The Ultimate Digital Storage Capacity for Ultrasonic Delay Lines" by C. F. West, H. N. Beveridge, and John DeTurk, all of the Raytheon Manufacturing Company, Waltham, Mass., was presented by Beveridge. The three factors which limit the storage capacity of mercury delay lines, as used for high-speed memory in digital computers were considered. These factors: the delay time, the bandwidth, and closeness with which the pulses can be packed were discussed. Transmission losses due to beam spreading were described. Slides were shown to give the basic components of the memory-circulation path and the details and characteristics of the tank type of mercury delay line.

"An Octal System Automatic Computer" by J. R. Weiner, J. P. Eckert, Jr., and J. W. Mauchly was delivered by Weiner. A description of the binac computer using the octal system for placing data in a machine was given. Results of tests on this all-electronic computer, which has fewer than 700 tubes, were explained. Slides disclosing schematic and block diagrams were shown. After presentation of the paper, a discussion followed on the comparison of the binary and octal system, on means of checking, and on results of the present tests. The operating temperature and power consumption of the computer, and the use of crystal diodes in the circuits were explained.

A description of the new computer, "The EDVAC," was given by R. L. Snyder, of the University of Pennsylvania, Philadelphia, Pa. It was described as a large-scale automatic digital computer intended to solve mathematical problems in which the numerical operations are too extensive to be performed manually. It is now undergoing the tests necessary to be put into operating conditions. Slides illustrating a setup of the equipment were shown, and the methods by which the information goes into the computer and flows through the system were explained. A description of the recent test procedures on the computer and the necessary corrections to design that were necessary were told. Questions were brought up and answered concerning the use of the magnetic tape and its advantages of providing an overflow when the computer is given more information than it can handle.

High-Frequency Cables Is Technical Session Subject

E. W. Greenfield of the Anaconda Wire and Cable Company, Hastings-on-Hudson, N. Y., presided at a session on February 3 on the subject of high-frequency cables. Three technical papers were presented.

John W. E. Griemsmann of the Polytechnic Institute of Brooklyn, Brooklyn, N. Y., spoke on the subject "Coaxial Line Supports of Optimum Voltage-Standing-

Wave-Ratio Performance." Consideration was given to mechanical and electrical requirements for supports. The reflection summation formula which covers most cases of dielectric bead structures was discussed. Various structures including the constant characteristic impedance bead types, the characteristic impedance deviation types, and the thin bead types were considered. Following the paper, comments were made on the evaluation of this method, on the practicability of having the voltage-standing-wave-ratio approach the optimum of one, and on the adaptability of connectors.

"Heating of Radio-Frequency Cables" was described by W. W. Macalpine of Federal Telecommunications Laboratories, Inc., Nutley, N. J. Details of the generation and diffusion of heat throughout the cables, which deals with the subject of how thermal standing waves arise and how they may be accounted for, was presented. Formulas have been developed for computation of the steady-state distribution of temperature along each conductor and in the dielectric, with principal emphasis upon applications to solid-dielectric coaxial cables. As yet, no experimental program has been carried out.

The paper, "The Power Rating of Radio-Frequency Cables," by R. C. Mildner of the Telegraph Construction and Maintenance Company, Ltd., London, England, was presented by A. G. Jenson of the Bell Telephone Laboratories, Inc., Murray Hill, N. J. The deleterious effects caused by exceeding the power limitations of the radio-frequency cable were discussed. It is proposed that specific ratings should be given to radio-frequency cables. Formulas for the heat dissipation corresponding to a specified maximum temperature rise in the line, for the thermal resistance of cables, and for the safe power rating of cables, were given. A chart was presented to give the power ratings of solid-dielectric flexible cables. Following the presentation, the practicability of current rating of radio-frequency cables, and the need for a new terminology were discussed.

PERSONAL NOTES.......

F. B. Jewett (A '03, F '12, Honorary Member '45), formerly chairman of the board, Bell Telephone Laboratories, New York, N. Y., and former president of the National Academy of Science, has accepted an appointment as a member of the board of trustees, Battelle Institute, Columbus, Ohio, an industrial and scientific research organization. Recipient of both the Edison and Faraday Medals, Jewett has been very active in AIEE affairs. A partial list of his AIEE committee memberships include: Edison Medal, 1917–19, 1922–25; Executive Medal, 1918–19, 1922–25; protective devices, 1915–16; research, 1920–22; Standards, 1914–16; telegraphy and telephony, 1914–17; Engineering Foundation board, 1919–25; education, 1925–26; Hoover Medal board of award, 1931–37; code of principles of professional conduct, 1928–42 (chairman, 1929–33); Lamme Medal, 1934–37; co-operation with war agencies, 1942–45.

A. S. Moody (A '09), commercial vice-president in charge of customer relations work in the northwestern states, General Electric Company, Portland, Oreg., has retired after 42 years of service to the company. He joined the Stanley Company, San Francisco, Calif., a subsidiary of General Electric, immediately after graduating from the University of California in 1906. In 1914, he became vice-president of the Pacific States Electric Company, later to become the General Electric Supply Company. Moody was named manager of the General Electric Los Angeles, Calif. office in 1923, and moved to the Portland office in 1924. He was made a commercial vice-president in 1938, and a member of the president's staff in 1945. He is a life member of AIEE.

J. E. White (A '39, M '45) has been appointed chief of the electron tube section of the Electronics Standards Laboratory, National Bureau of Standards. He will be responsible for planning, conducting, and co-ordinating research on electron tubes, including cathode, gas discharge, and microwave problems, and development of classified tubes for ordnance devices and electronic computors. Before joining the Bureau of Standards in 1946, Doctor White was a member of the Westinghouse Electric Corporation's special experimental tube group, and prior to World War II, had been on the faculties of the Universities of Pittsburgh and West Virginia. He holds membership in the American Physical Society, and Sigma Xi, Sigma Pi Sigma, and Eta Kappa Nu fraternities.

H. C. Dean (A '12, F '30), vice-president oi the Consolidated Edison Company of New York, Inc., in charge of Brooklyn and Queens, has been appointed chairman of the Brooklyn committee to sponsor Junior Achievement companies. Under the plan, business firms sponsor various types of companies to be run by young people, and provide volunteer advisers in all departments, such as production, sales, administration. The motto of the program is "learn by doing." Dean, always active in civic affairs, is a member of the Brooklyn chamber of commerce and the board of education. He has been active in AIEE affairs, having been on the following committees: power transmission and distribution, 1929-32; board of examiners, 1934-37 (chairman, 1936-37); legislation affecting the engineering profession 1934-37.

E. W. Dillard (A '16, F '46), a director of the New England Power Service Company, Boston, Mass., has been named chief engineer for that company. A relay specialist, Dillard has been with the New England power system since 1916, and has been electrical engineer for his company since 1927. Included among the AIEE committees of which he was a member are: transmission and distribution, 1928-30, 1947-49; protective devices, 1928-29; power generation, 1932-33. **H. R. Stewart** (A '26, F '46), since 1934 protection engineer for the company, will succeed Dillard as electrical engineer, and will be assisted by **Harris Barber** (A '30), former electrical design engineer. Stewart has been on the AIEE protective devices committee from 1937 to 1949, and Barber has been a member of the AIEE substations committee from 1945 to the present.

E. T. B. Gross (A '34, F '48), professor of power systems engineering, Illinois Institute of Technology, Chicago, Ill., has been elected president of the Chicago Alumni chapter of the Eta Kappa Nu association for the next year. Doctor Gross has served on the AIEE protective devices committee, 1947-48, and the relays committee, 1947-49. **G. M. L. Sommerman** (A '31, M '37), associate professor of electrical engineering, Northwestern Technological Institute, Evanston, Ill., was elected vice-president. He has been a member of the following AIEE committees: instruments and measurements, 1934-43; research, 1936-39, 1944-46; insulated conductors, 1948-49.

E. W. Seeger (A '16, F '36), vice-president in charge of development, Cutler-Hammer, Inc., Milwaukee, Wis., has been elected a vice-president of AIEE, repesenting the Great Lakes District (District 5) for the remainder of the two-year term ending July 31, 1950. Seeger is replacing **Ira A. Terry** (A '27, F '37) who resigned effective November 1, 1948, because of removal from that District. Seeger has been on the AIEE automatic stations committee, 1927-29, and the AIEE applications to iron and steel production committee, 1935-37. Terry was a member of the AIEE board of examiners, 1944-46.

F. C. Bolton (A '09, F '42), formerly vice-president and dean of the college, Texas Agricultural and Mechanical College, College Station, has been installed as president of that institution. Doctor Bolton joined the faculty in 1909 as a teacher of electrical engineering and was named dean of all engineering in 1922. Ten years later, he was named dean of the college. Active in AIEE affairs, Bolton has served on the following committees: education, 1936-41; membership, 1938-39; board of directors, 1938-40; legislation affecting the engineer, ing profession, 1940-41; Institute policy, 1941-42.

J. J. Gilbert (A '13), Bell Telephone Laboratories, Inc.; **C. H. G. Gray** (A '29), Bell Telephone Laboratories, Inc.; **J. E. McCormack** (A '27, F '44), Consolidated Edison Company; **Jacob Millman** (A '37, M '47), College of the City of New York; **R. W. Prince, Jr.** (A '40), Bell Telephone Laboratories, Inc.; **H. O. Siegmund** (A '19, F '45), Bell Telephone Laboratories, Inc.; and **J. F. Wentz** (A '24, M '42), Bell Telephone Laboratories, Inc., all of New York, N. Y., have been presented the Army-Navy Certificate of Appreciation for outstanding contributions to the Office of Scientific Research and Development during World War II.

H. E. Wulfing (M '23, F '44), system planning engineer, Commonwealth Edison Company, Chicago, Ill., has retired after 40 years of service. Employed as superintendent of outside plant in 1909, he subsequently became superintendent of overhead lines, engineer of a-c substations, and staff engineer, before attaining his present position. Among the many engineering techniques developed by Wulfing was the remote control substation, so successful that all a-c substations built since 1920 have been of this type. A frequent contributor to engineering and scientific journals, Wulfing also served on the following AIEE committees: power generation, 1936–37; power transmission and distribution, 1936–44; transmission and distribution, 1943–48; technical program, 1943–45; Standards, 1943–45; award of Institute prizes, 1943–45.

F. R. Benedict (A '40, M '47) has been appointed manager of the headquarters engineering departments of the Westinghouse Electric Corporation, East Pittsburgh, Pa. He will be responsible for the operations of industry and foreign engineering, the engineering laboratories, and the standards departments. He was formerly manager of the industry engineering department and has been with the company since 1928. Benedict is a member of the following AIEE committees: chemical, electrochemical, and electrothermal applications, 1946–49 (chairman, 1948–49); industry co-ordinating, 1948–49; Standards, 1947–49; technical program, 1948–49.

H. V. Nye (A '20, F '40) has been named consulting engineer for the switchgear section, electrical department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis. He has been with the company since 1906, and has served on the following AIEE committees: protective devices, 1934–37, 1940–47; switchgear, 1947–49; Standards, 1948–49. **T. G. A. Sillers** (A '26, M '43), engineer in charge of the development, switchgear, and control sections for the company's electrical department during the past two years, will replace Nye as engineer in charge of switchgear design. Sillers was a member of the AIEE transmission and distribution committee in 1947–48.

C. C. Cornelius (A '29, M '32) has become manager of overhead systems and assistant to the manager of operations for the Kansas Light and Power Company, Kansas City, Mo. He will be assisted by **S. H. Pollack** (A '30, M '36) who has been named assistant superintendent of overhead systems. **C. M. Lytle** (A '31, M '42) will head a newly established engineering department for the company and will be assisted by **J. C. Davis** (A '23, M '30), new assistant transmission and distribution engineer. **I. T. Knight** (A '25, M '42) has been appointed superintendent of the substation department. Knight served on the AIEE substations committee from 1945 to 1948, and on the carrier current committee, 1947–48.

L. A. Doggett (A '13, F '36), professor of electrical engineering, Pennsylvania State College, State College, Pa., has retired as of February 1, 1949, with emeritus rank after 26 years of service at that institution. A graduate of Harvard University, Cambridge, Mass., he taught there from 1910 to 1913, and then spent ten years as professor of electrical engineering at the United States Naval Academy, Annapolis, Md. He came to Pennsylvania State College in 1923 and remained until the date of his retirement. Doggett has been active in AIEE affairs, having served on the following AIEE committees: marine, 1917–19; education, 1924–25, 1933–36; Student Branches, 1933–37; Sections, 1933–35; technical program, 1933–35; publications, 1934–35.

B. W. Kendall (M '18, F '29), research consultant, research and patent department, Bell Telephone Laboratories, Inc., New York, N. Y., has retired after 35 years with that company. Joining the Bell System in 1913, he worked on early transcontinental and transatlantic radio-telephone experiments. In 1915, he worked on carrier communications, and in 1919, on toll circuits and transmission. He holds 26 patents for work in this field. Kendall was put in charge of fundamental circuit investigations in 1940, but transferred to the patent department in 1945.

A. H. Frampton (A '21, F '45) has resigned from the staff of the Hydro-Electric Power Commission of Ontario, Toronto, Ontario, Canada, to accept an appointment as general manager of the English Electric Company, St. Catherine's, Ontario, Canada. Frampton is chairman of the AIEE power generation committee, of which he has been a member since 1942. He is also on the Standards, technical program, and power co-ordinating committees for 1947–49, and was on the Sections committee in 1946–47.

F. L. Lewis (A '31, M '35), technical writer and publications consultant, has become associated with Dudley, Anderson, and Yutzy, public relations counsel, New York, N. Y. Lewis was a member of the AIEE editorial staff for 14 years, having been assistant editor (1931–36), associate editor (1936–42), and acting editor-in-chief (1942–45). He also served as secretary to the AIEE publications committee from 1931–45, and as a full member in 1946–47.

J. C. Fink (A '46), formerly manager of the general mill section, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been appointed as manager of the industry engineering department of that company. He has been with the company since 1927, and from 1928 to 1945 was a member of the marine and aviation section of the department he now will head. Fink is a member of the AIEE general industry applications committee for 1947–49.

F. R. Kappel (M '43), vice-president in charge of operations, Northwestern Bell Telephone Company, since 1942, has been appointed an assistant vice-president in the operation and engineering department, American Telephone and Telegraph Company, New York, N. Y.

N. D. Glyptis (A '43), electron beam authority, has been named director of the recently established Multi-Tron Laboratory, Chicago, Ill. At 27, he is perhaps the youngest consulting physicist in the United States, and already has contributed several inventions and designs to electron beam tube development.

P. M. Craig (A '34, F '38), chief engineer, radio division, Philco Corporation, Philadelphia, Pa., has been named director of engineering, electronics division of the engineering department, for that company. He has been with Philco for 15 years, and during World War II, was chief engineer in charge of radar and military radio development.

A. B. Cooper (M '16, F '33), president of Ferranti Electric Limited, Toronto, Ontario, Canada, and first president of the Canadian Electrical Manufacturers Association, has been appointed chairman of the Canadian National Committee, part of the International Electrotechnical Committee. He has been a member of the following AIEE committees: lighting and illumination, 1920–23; membership, 1926–27, 1936–39; electric machinery, 1928–29, 1933–36; Standards, 1931–36.

William Kelly (F '25), former United States Army colonel and chief of the public utilities section, industrial branch, Office of Military Government, has returned to the presidency of the Buffalo Niagara Electric Corporation, Buffalo, N. Y., after an absence of two years spent in Germany, rehabilitating German public utilities.

R. F. Pulver (M '46), vice-president of the Minnesota Power and Light Company, has been elected chairman of the North Central Electrical Industries.

J. A. Tyvand (M '37, F '45) has resigned as chief electrical engineer of the Otter Tail Power Company, Fergus Falls, Minn., to become chief electrical engineer of the consulting firm of Knappen Tippetts Abbett Engineering Company, New York, N. Y. He has been active in Midwest utility work for the past 25 years.

E. B. Eggers (M '47) and **D. H. Pickens** (A '47), have been named engineer and assistant engineer respectively to the staff of the Armour Research Foundation of the Illinois Institute of Technology, Chicago.

E. E. Hill (A '16), assistant to the executive vice-president, Consolidated Edison Company of New York, Inc., has been elected for a 3-year term to the board of trustees of the Polytechnic Institute of Brooklyn, N. Y. as representative of the institute's alumni. Hill received his degree in electrical engineering from the Polytechnic Institute in 1917. He is serving on the 1947–49 AIEE management committee.

R. F. Edwards (A '41, M '46), formerly design engineer for the Westinghouse Electric Corporation, has been appointed section engineer in charge of synchronous motors and vertical generators for the Ridgway division, Elliott Company, Jeanette, Pa.

R. R. Richart (M '47), formerly associate editor of *Coal Age* magazine, McGraw-Hill Publishing Company, New York, N. Y., has resigned his position to join the engineering staff of the Chicago, Wilmington and Franklin Coal Company, Benton, Ill. His first assignment will be on the construction of a preparation plant at the company's Orient number 3 mine, Waltonville, Ill.

G. L. Weller (M '26, F '31), chief engineer, Chesapeake and Potomac Telephone Company, Washington, D. C., has resigned to open his own consulting engineering office in Washington, D. C. Weller was with the Bell Telephone system for 47 years.

H. A. Schlieder (A '33) has resigned as chief engineer of the Northern Equipment Company, Erie, Pa., to open offices as sales and service representative, Syracuse, N. Y.

G. H. Groh (M '43), chief engineer and general superintendent of the Central Arizona Light and Power Company, has been elected vice-president in charge of operations. He joined the staff of that company in 1929 and rose through the ranks to become chief engineer in 1945. Groh is a member of the AIEE committee on systems engineering for 1948–49.

J. H. Burrus (A '47) has been promoted to manager of the Allis-Chalmers Portland, Oreg., office. He was formerly assistant manager, and has been with the company in its West Coast offices since 1937.

R. M. Somers (A '29, M '42), assistant chief engineer since 1936 for the Ediphone division of Thomas A. Edison, Inc., West Orange, N. J., has been appointed chief engineer. He joined the Edison company in 1928 as a research engineer, and later served as chief engineer and factory superintendent of the former lamp division.

J. W. Cable (A '38), formerly director of research and sales for the Induction Heating Corporation, Brooklyn, N.Y., has opened offices in New York, N.Y., as a consultant in the high-frequency heating field. He will specialize in both induction and dieletric heating, and will offer engineering and design services.

R. B. Beetham (A '36), assistant to the president, Collins Radio Company, Cedar Rapids, Iowa, has joined the staff of Airborne Instruments Laboratory, Mineola, N.Y. He will serve as executive assistant to the vice-president in charge of research and engineering. He is a former member of the Radio Technical Planning Board and the technical committee of the Telecommunications companies conducted by the Department of State, and from 1945 to 1947, was a member of the AIEE communications committee.

E. E. Sheldon (A '40, M' 43) has been appointed staff assistant to the manager of manufacturing of the General Electric Company's construction materials department, Bridgeport, Conn. Sheldon was formerly quality control engineer of the wire and cable division and was with that division since joining the company in 1937.

J. M. Nelson (A '43), senior engineer with the Seattle (Wash.) City Light Department, has been promoted to assistant superintendent. He has held various operating and engineering positions with Seattle City Light since joining them 12 years ago.

P. Diamond (A '47), formerly electrical engineer, Stone and Webster Engineering Corporation, Los Angeles, Calif., has been appointed application engineer for the International Rectifier Corporation, Los Angeles. Diamond was a former president of the AIEE Student Section at City College of New York, New York City.

R. C. Lewis (A '32, M '43) has been promoted from lecturer to associate professor of electrical engineering at the University of Southern California, Los Angeles, Calif. **F. J. Clark** (A '44) has been added to the faculty as an instructor in electrical engineering. He was formerly an instructor at Purdue University, Lafayette, Ind.

D. I. Anzini (M '37), sales engineer, General Electric Company, San Francisco, Calif., has been made manager of the electric utility section, central station division, for that company's San Francisco office. He is a past chairman and present vice-chairman, of the AIEE San Francisco Section and has been on the Sections committee, 1946-49.

R. L. Halsted (A '44) has been named manager of the Allis-Chalmers Cleveland, Ohio, office effective December 1, 1948. Halsted, a graduate of the University of Michigan, has been manager of the Charleston, W. Va., office since 1942. He joined the company in 1935, and served in the Cincinnati, Ohio, office for a number of years before establishing the Charleston branch.

W. R. Phillips (A '44, M '45) is now chief engineer of the Larkin transformer division, Larkin Lectro Products Corporation, New York, N. Y. He has been engaged in the design of power, distribution, and special transformers since 1923.

J. W. Dice (A '41), formerly with the Westinghouse Electric Corporation and more recently assistant sales manager for the Sperry Company, has formed his own sales and development organization, to be known as J. W. Dice and Company, with headquarters at Grand View-on-Hudson, N. Y.

K. W. Jarvis (A '25, M '34) has been named to head the new electronics department of the Automatic Electric Company, Chicago, Ill. Jarvis previously headed his own electronics consulting firm. The new department is planned to meet the needs of planning and equipment service devoted to electronic applications for railroads and other industries.

J. R. Read (A '04), president of the Canadian Westinghouse Company, Ltd., Hamilton, Ontario, Canada, has been awarded the order of an Officer of the British Empire for his contributions in the administration of a government program involving millions of dollars during World War II. He acted as liaison officer between a steel company and the government on a contract for $20,000,000 to be used in the production of gun barrels and armament parts.

Y. T. Chaney (A '40, M '45) has been named manager of the distribution systems of the Trumbull Manufacturing Company, Plainville, Conn. He joined the firm in 1937 in the engineering department of their plant in Ludlow, Ky., and in 1945 was named resident engineer.

C. W. Cutler (M '47), consulting power engineer, has joined the Seattle (Wash.) City Lighting department in the newly created position of Skagit project engineer.

H. V. Strandberg (M '37), formerly supervising senior engineer in charge of electrical design and construction for that department, has been appointed project engineer on a 230-kv transmission line and receiving substation installation. Strandberg will be succeeded by **Hugh Silliman** (A '38, M '45) as supervising senior engineer.

G. F. Peirson (M '45) has been named chief engineer of the Midlands Electricity Board, Mucklow Hill, England. He was formerly a subarea manager for the board.

OBITUARY • • • •

Sampson K. Barrett (A '11, M '17), former assistant dean, college of engineering, New York University, New York, N. Y., died December 23, 1948. He was born September 7, 1886, at Saratoga Springs, N. Y., and received the degree of electrical engineer cum laude from the Brooklyn (N. Y.) Polytechnic Institute in 1910. From 1910 until 1915, Barrett was an instructor of electrical engineers at his alma mater working under Doctor Samuel Sheldon. During his period as an instructor, he aided Doctor Sheldon in development work on several electrical engineering projects. In 1915, Barrett was promoted to assistant professor of electrical engineering. From 1917 to 1919, he served in the United States Navy, and after his discharge, became an instructor at New York University. He served as associate director of the college of engineering evening division from 1927 to 1929, as director from 1929 to 1936, and as assistant dean in charge of the division until ill health caused his retirement in 1940. During 1940–41, Professor Barrett was director of the Defense Training Institute of the Engineering Colleges of Greater New York. He was the author of numerous technical papers on electrical illumination and wiring, and was a technical expert in important legal cases involving patents and insurance suits. During his teaching career, Barrett also did considerable consulting work. Active in AIEE activities, he was a member of the committee on the production and application of light from 1933 to 1934 and from 1938 to 1941. Among his many professional affiliations, Barrett included membership in the Society for the Promotion of Engineering Education, Illuminating Engi-

neering Society, the American Society of Mechanical Engineers, American Society for the Advancement of Science, New York Society of Professional Engineers, and the honorary engineering fraternities of Tau Beta Pi, Eta Kappa Nu, and Iota Alpha.

Reginald L. Jones (A '11, F '31), vice-president of the Bell Telephone Laboratories, New York, N. Y., died January 14, 1949. A native New Yorker, he was born February 28, 1886, and received his education at the Massachusetts Institute of Technology, taking the bachelor of science degree in 1909, the master of science degree in 1910, and the doctor of science degree in 1911. In that latter year, Jones joined the Western Electric Company's engineering department, which later became the Bell Laboratories. His early work was on telephone transmission problems and the creation of instruments to increase telephonic quality. In 1914, Jones was placed in charge of the transmission laboratory, but during the war years, was a captain in the United States Army Signal Corps. Returning to civilian life, Jones was appointed inspection manager and organizer of the first industrial group devoted to scientific quality control. When Western Electric became the Bell Laboratories in 1925, he added outside plant development to his work in inspection engineering, and in 1928 he became director of apparatus development. Jones was appointed a vice-president in 1944. Active in AIEE affairs, he was a member of the following committees: Standards, 1925–32, 1942–49; special committee on biographies and talking motion pictures, 1933–41; constitution and bylaws, 1942–49; planning and co-ördination, 1946–49; technical program, 1947–49. Jones was also a member of the Standards Council, American Standards Association, American Physical Society, the Acoustical Society of America, and the American Association for the Advancement of Science.

James A. Cadwallader (A '15, M '28, F '39), engineer of transmission and outside plant, Bell Telephone Company of Pennsylvania, Pittsburgh, Pa., died December 20, 1948. Born at Milton, Pa., he received his electrical engineering degree in 1912 from the University of Pennsylvania. He joined the Bell Telephone Company's Philadelphia office as a student engineer, and later served in the Harrisburg office. In 1918, Cadwallader was appointed division transmission engineer at Harrisburg, and in 1921, was transferred to Philadelphia as assistant engineer of transmission and protection. In 1922, he went to Pittsburgh as division transmission engineer, and in 1925, was made division plant engineer. He was appointed engineer of transmission and outside plant in 1926, the position he held until his death. Cadwallader was chairman of the AIEE Pittsburgh Section, 1929–30, and was a member of the Engineers' Society of Western Pennsylvania.

Robert S. Meyers (A '37, M '42), chief electrical engineer, technical staff, Rocky Mountain Arsenal, Denver, Colo., died December 12, 1948. Born August 30, 1905, he received his electrical engineering training while in the United States Navy, and later at New York University. He was chief design and electrical engineer for construction at Edgewood Arsenal, Md., and Huntsville Arsenal in Alabama. From 1928 to 1931, he was an instructor of power engineering at the Kearny, N. J. plant of the Western Electric Company, and later did design work there in the power engineering department. From 1931 to 1934, Meyers did designing, estimating, and supervising of industrial light, power, and signal installation construction for the Walpert Electric Company, Baltimore, Md. In July 1934, he became an engineer with the American District Telegraph Company, New York, N. Y., and was in charge of plant engineering problems, field tests, and inspections. He held this position for several years, but came to Denver in 1942 where he did the electrical design for the Rocky Mountain Arsenal. He remained on as chief electrical engineer at the arsenal until his death. His professional affiliations included the Military Engineers of America, the International Association of Electrical Inspectors, and the Colorado Society of Engineers.

George A. Kelsall (A '10), lecturer in mathematics, Newark (N. J.) College of Engineering, died January 4, 1949, He was born October 18, 1880 in Louisville, Ky., and was a 1906 graduate in electrical engineering from the Rose Polytechnic Institute. For a year and a half after graduating, Kelsall was employed in the testing department of the General Electric Company. In 1912, he joined the Western Electric Company to do development work in new magnetic materials in that company's physical laboratory. In 1917, he directed his efforts to fundamental studies of magnetic materials, including about 2,500 alloys of different compositions. For his work in this field, he has been credited with nearly a hundred inventions and numerous patents. He retired about three years ago from his duties as an engineer and took the position as lecturer in mathematics to occupy his time. Kelsall was also a member of the American Physical Society.

Charles M. Stayner (A '20, M '45), assistant electrical engineer, Union Pacific Railroad Company, Salt Lake City, Utah, died November 19, 1948. Born in Farmington, Utah, on April 15, 1881, he was a graduate of the University of Utah. From 1906 to 1909, he was a switchboard installer for the Pacific Telephone Company, San Francisco, Calif., and then spent two years in Mexico as a surveyor and pump installer for Graham and Sons. From 1911 to 1939, Stayner was electrical construction supervisor for the Oregon Short Line Railroad, Salt Lake City. When the railroad changed its name to the Union Pacific in 1939, he became assistant electrical engineer in charge of selection and installation of all electric equipment in the Union Pacific's South Central district, the position he held until his death.

David Alva Powell (M '45), executive vice-president of the Iowa Power and Light Company, Des Moines, died December 19, 1948. He was born in Blue Mounds, Wis., on September 4, 1883, and received his degree in electrical engineering from the University of Wisconsin in 1907. From 1907 to 1910, he served as a cadet engineer with the Madison (Wis.) Gas and Electric Company, and from 1910 until 1925, was with the Milwaukee (Wis.) Gas and Light Company in the construction, operations, and appraisals departments. From 1926 until 1932, Powell was president of the Muskegon (Mich.) Traction Company, specializing in gas and transportation utility property. He became vice-president and general manager of the San Antonio (Tex.) Public Service Company in 1932 and remained there until 1942. In 1943, Powell became executive vice-president of the Iowa utility, the position he held until his death.

Norman Mackenzie (A '43), executive secretary of the Eastern Washington Public Utility Districts, died December 13, 1948. Born in Winnipeg, Manitoba, Canada, on July 12, 1895, he received his technical education at Manitoba University, graduating in 1906. From 1920 until 1924, he was general superintendent in charge of transmission line construction for the Manitoba Power Commission. Between 1925 and 1936, Mackenzie held various positions with companies in both Canada and the United States. In that latter year, he organized and managed the Colville Engineering Company, Colville, Wash., where he designed and constructed approximately 6,000 miles of rural electrification lines. His company also handled the construction of substations, regulator stations, and city and town distribution systems throughout eastern Washington.

Robert J. Needham (M '23), retired electrical and mechanical engineer, died October 25, 1948. He was born in 1882 at London, Ontario, Canada, and was a 1910 graduate of McGill University, Montreal, Canada. After holding various positions with companies in the metropolitan New York area, he joined the Detroit (Mich.) Edison Company as a chief operator from 1910 to 1911. From 1911 until the 1920s, Needham was electrical engineer in charge of investigations and installations for the Grand Trunk Railway of Canada. When that company changed to the Canadian National Railway, Needham remained on as electrical engineer until he retired in 1947. For the past year, he had been doing general consulting engineering. A member of The American Society of Mechanical Engineers, he also served on the AIEE transportation and land transportation committees from 1938 to 1942.

Frank H. Mason (A '10), chief engineer, New England Public Service Company, Augusta, Me., died December 17, 1948. He was born in Somerville, Mass., on February 25, 1879, and received his technical training at the Massachusetts Institute of Technology and the Rensellaer Polytechnic Institute. From 1901 to 1906, Mason was with the Hudson River Electric Power Company, Albany, N. Y., as assistant engineer on the layout of high-voltage lines. For the next three years, he held various engineering jobs with New England utilities, and in 1909, he joined the Central Maine Power Company as engineer in charge of development. He was with Maine utilities until his death. In 1947–48, Mason served on the AIEE electric heating committee.

Maurice M. Samuels (F '24), consulting engineer, New York, N. Y., died January 29, 1949. He was born in Lithuania on November 16, 1880, and was educated at the University of Freiburg, Switzerland, and the University of Karlsruhe, Germany. Upon coming to the United States, he was employed by the General Electric Company, Schenectady, N. Y., from 1906 to 1907 as a draftsman, and as an electrical designer for the Westinghouse, Church, Kerr and Company, New York, N. Y., from 1907 to 1910. From then until 1931, Samuels was with the J. G. White Engineering Corporation, New York, as a technical surveyor for utility systems. From 1934 to 1938, he was electrical engineering technical adviser for the Federal Power Commission. He was chief research engineer, division of engineering and operations in 1939–40, and chief of the technical standards division in 1940–46. From 1946 to his death, Samuels was consulting engineer for both governmental and industrial groups. He was a member of the AIEE committees on power generation, 1924–27, and power transmission and distribution, 1941–42.

Frederick W. L. Hill (M '24, F '34), aerial lines engineer, Potomac Electric Power Company, Washington, D. C., died January 12, 1949. He was born in Narcoossee, Fla., August 27, 1893, and received his technical training from the University of Florida. He was employed by the New York Edison Company from 1915 to 1922, with the exception of a year and a half spent in the United States Army, 1917–18. From 1922 to 1933, Hill was assistant electrical engineer and distribution engineer for the Electric Bond and Share Company, New York, N. Y. He joined the Potomac Company in 1933 as an electrical engineer, and was with the company until his death. From 1947–49, Hill was a member of the AIEE committee on the registration of engineers. He was also a director of the National Society of Professional Engineers, and a member of the International Association of Electrical Inspectors.

Elwood Bachman (M '40), consulting engineer, Salt Lake City, Utah, died December 14, 1948. He was born in Provo, Utah, on August 5, 1891, and received his degree in electrical engineering from the University of Utah in 1916. Starting as early as 1909, Bachman held various positions in the electrical field in and around Utah. In 1916, he entered the student engineering course of the General Electric Company, Schenectady, N. Y., and in 1917, moved to their Pittsfield, Mass., works, in the transformer engineering department. In 1918, he became a transformer specialist at the company's Cincinnati, Ohio, office. In 1920, Bachman became a consulting engineer in Salt Lake City, and from that year until his death acted in this capacity for numerous industrial concerns in the western United States and Canada.

Edgar J. C. Herring (A '29, M '36), managing director, Jost's Engineering Company, Limited, Bombay, India, died October 28, 1948. Born in Beckenham, Kent, England, on March 12, 1891, he received his electrical engineering training at the South Western Polytechnic, Chelsea, London, England. After two years as shift engineer in the Sutton Power Station, Surrey, England, and four years with the Brush Electrical Engineering Company Limited, Loughborough, England, as a design engineer, Herring became manager of the Calcutta branch of the Jost Company in India in 1916. From 1924 on, he was manager of the company. Herring was also a full member of the Institution of Electrical Engineers, London.

William McLean (M '42), superintendent of electrical distribution, Consolidated Gas, Electric Light and Power Company, Baltimore, Md., died December 17, 1948. He was born in Baltimore on November 28, 1894, and was graduated from the University of Maryland in 1916. Except for 16 months in 1917–18 as a lieutenant in the United States Army Engineers, and two years spent farming in 1920–22, McLean was employed as an estimator in the electric distribution department of the Baltimore Gas and Electric Company from 1922 to 1939 when he was made assistant superintendent. He became superintendent in 1941 and was in charge of all engineering planning and construction.

George T. Twyford (A '21), electrical engineer, Potomac Edison Company, Hagerstown, Md., died December 6, 1948. Born August 3, 1885, in Hebron, W. Va., he was a 1911 graduate of West Virginia University. After a two year period in the industrial and dynamo testing department of the Westinghouse Electric Manufacturing Company, East Pittsburgh, Pa., he became an electrical engineer for the Pittsburgh Harmony Butler to New Castle Railroad. In 1917, Twyford joined the Potomac Company and was placed in charge of substation maintenance and construction and transmission engineering. He remained with that company in various engineering capacities until his death.

Albert E. Orwell (A '44), mechanical superintendent of the wire and cable division of Northern Electric Company Limited, Montreal, Quebec, Canada, died recently. Born December 28, 1905, at Kingston, Ontario, Canada, he received his electrical engineering degree from Queen's University in that city in 1930. Orwell joined the Northern Electric Company in 1929, and from then until 1940 he designed underground cables. He switched to the manufacture of electric wires and cables in that year, and was promoted to assistant master mechanic in 1942. In 1943 he was made master mechanic and in 1946 he was appointed to the position he held at his death, that of mechanical superintendent.

George C. Day (A '45), generator engineering division, General Electric Company, Lynn, Mass., died November 13, 1948. Born in New Brunswick, Canada, on August 8, 1917, he was a graduate of the University of New Hampshire, 1939, and received his master of science degree in electrical engineering from the Case School of Applied Science in 1942. He joined the General Electric Company as a test engineer in 1942, and held that position at the company's Cleveland, Ohio, Erie, Pa., and Lynn, Mass. plants, the latter until his death.

Robert J. Graf (A '11), chairman of the board and former president of H. M. Byllesby and Company, investment bankers, Chicago, Ill., died January 2, 1949. He was born in Washington, D. C., on November 13, 1882. He joined the Byllesby Company at the age of 20, in 1902 when the company was first formed. He acted as secretary and assistant treasurer until being elected a vice-president in 1914. In 1924, Graf was made first vice-president and in 1936, he was elected to the presidency. He became board chairman in 1946. In the course of his career, Graf held executive positions with the Byllesby Engineering and Management Corporation, Standard Gas and Electric Company, Standard Power and Light Corporation, plus a number of their subsidiaries and affiliates. He was also a member of the old National Electric Light Association, and its successor, the Edison Electric Instiute.

MEMBERSHIP . . .

Recommended for Transfer

The board of examiners at its meeting of Janaury 20, 1949, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Fellow

Douglass, G. W., chief engr., New Jersey Bell Tel. Co., Newark, N. J.
Harness, G. T., Jr., head, dept. of elec. engg., University of Southern Calif. Los Angeles, Calif.
Millermaster, R. A., asst. mgr. of development, Cutler-Hammer, Inc., Milwaukee, Wis.
Newman, J. M., general supervisor of engg., Cutler-Hammer, Inc., Milwaukee, Wis.
Thacker, M.S., prof. & head dept. of power engg., & electrical technology, Indian Institute of Science, Bangalore, India
Waters, J. S., prof. & head of elec. engg. dept., Rice Institute, Houston, Tex.
Wyatt, F. D., elec. engr., Chicago Park District, Chicago, Ill.

7 to grade of Fellow

To Grade of Member

Bonheimer, H. E., senior engr., Cleveland Electric Illuminating Co., Cleveland, Ohio.
Barrett, T. L., Jr., design engr., Duquesne Light Co., Pittsburgh, Pa.
Bartlett, P., patent specialist, power circuit breaker div., General Elec. Co., West Philadelphia, Pa.
Bulkley, O. R., asst. chief, div. of elec. engg., Southern California Edison Co., Los Angeles, Calif.
Clark, D., electrical engg. section head, U. S. Bureau o Reclamation, Denver Federal Center, Colo.
Craig, D. E., sales mgr., unit substation section, General Electric Co., Schenectady, N. Y.
Cwiklo, E. C., design engr., General Electric Co., Ft. Wayne, Ind.
Doak, W. M., mgr. of utilities, basic magnesium project, Colorado Commission of Nevada, Henderson, Nev.
Dowsley, C. L., chief electrical draftsman, Burrard Drydock Co., Ltd., N. Vancouver, British Columbia, Canada
Easton, I. G., engr., General Radio Co., New York, N. Y.
Kight, M. H., asst. head, electrical div., Bureau of Reclamation, Denver Federal Center, Denver, Colo.
Leslie, J. R. A., research engr., Hydro-Electric Power Commission, Toronto, Ontario, Canada
Nettles, J. C., aeronautical research scientist, N.A.C.A. Cleveland Municipal Airport, Ohio
Patton, W. S., field engr., James R. Kearney Corp., St. Louis, Mo.
Pfenninger, G. C., senior engr., Kodak Park works, Eastman Kodak Co., Rochester, N. Y.
Porter, W. A., district supt., Public Service Co. of Colorado, Alamosa, Colo.
Price, A. L., asst. to supt. of generation, Pennsylvania Power & Light Co., Hazleton, Pa.
Sinish, R. D., development engr., government projects div., Farnsworth Television & Radio Corp., Ft. Wayne, Ind.
Stoelting, H. O., research engr., Line Material Co., Milwaukee, Wis.
Strom, R. L., chief elec. engr., Pacific Island Engineers, San Francisco, Calif.
Ungrodt, A. L., engr., Commonwealth Edison Co., Chicago, Ill.

Weyerts, E. E., area engr., General Electric Co., Richland, Wash.
Wheeler, B. G., elec. engr., Cutler-Hammer, Inc., Milwaukee, Wis.
Works, C. N., research engr., research labs., Westinghouse Electric Corp., East Pittsburgh, Pa.

24 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before March 21, 1949, or May 21, 1949, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Ahmed, M. A.-H., Foad I University & Elec. Development Co., Cairo, Egypt
Allen, J. B., Boeing Airplane Co., Seattle, Wash.
Andrews, R. J., Sangamo Elec. Co., Jackson Mich.
Auger, G., Aluminum Co. of Canada, Shawinigan Falls, Quebec, Canada
Bishop, D. O., The Polytechnic, London, England
Bradstrum, R. E., Michigan Bell Tel. Co., Detroit, Mich.
Brumgard, L. S., General Elec. Co., Philadelphia, Pa.
Brunner, H., Service Elec. Co., Jacksonville, Fla.
Burgett, C. A., Public Service Co. of Okla., Tulsa, Okla.
Bush, H. F., Bell Tel. Co. of Canada, Montreal, Quebec, Canada
Butcher, F. E., Electro Methods Ltd., London, England
Camp, J. H., Holyoke Water Power Co., Holyoke, Mass.
Chapman, J. F., Westinghouse Elec. Corp., Newark, N. J.
Dale, E. E., Crown Zellerbach Corp., Seattle, Wash.
Darling, H. H., Ontario Provincial Gov't., Toronto, Ontario, Canada
Dickey, J. R., Central Power & Light Co., Corpus Christi, Tex.
Dow, A. L., Board of Public Utilities, Paris, Tenn.
Ellis, T. F., Kaiser-Frazer Corp., Willow Run, Mich.
Fischer, F. P., Univ. of Connecticut, Storrs, Conn.
Fitzgerald, J. D., General Elec. Co., Chicago, Ill.
Forbes, J. C., General Elec. Co., New York, N. Y.
Gallagher, K. R., The Hydro-Elec. Power Comm. of Ontario, Haileybury, Ontario, Canada
Geisler, L. W., Jr., Public Service Elec. & Gas Co., Newark, N. J.
Griggs, R. W., Raytheon Mfg. Co., Baltimore, Md.
Hauffe, F. H., Louisiana Power & Light Co., New Orleans, La.
Helt, S., Allen B. DuMont Labs., Passaic, N. J.
King, W. C., Cornell-Dubilier Elec. Corp., Los Angeles, Calif.
Lanphier, R. C., Jr., Sangamo Elec. Co., Springfield, Ill.
Laschiver, H., Dept. of Army, New York, N. Y.
Lund, E. W., Thomas B. Thrige, Odense, Denmark
MacAdam, W. K., American Tel. & Tel. Co., New York, N. Y.
Matthews, R. W., California Div. of Highways, Sacramento, Calif.
Menon, B. V. D., Seshasayee Brothers Ltd. (Travancore), Alwaye, South India
Munneke, A. S., Stanolind Pipe Line Co., Tulsa, Okla.
Myers, G. B., Picker X-Ray Corp., New York, N. Y.
Purnell, A. T., Bremang Gold Dredging Co., Ltd., Gold Coast Colony, South Africa
Roman, J. W., Kansas State College, Manhattan, Kan.
Salibury, T. M., P. O. Box 1085, Jackson, Miss.
Sing, W. Y., Hongkong Elec. Co., Hong Kong, China
Smith, J. I., The Shawinigan Water & Power Co., Three Rivers, Quebec, Canada
Steere, L. E., Jr., Potomac Elec. Power Co., Washington, D. C.
Upton, L. W., Nash Kelvinator Corp., Kenosha, Wis.
Wimpenny, N., Ministry of Fuel & Power, Bath Somerset, England

43 to grade of Member

To Grade of Associate

United States Canada, and Mexico

1. North Eastern

Abetti, P. A., General Elec. Co., Pittsfield, Mass.
Alexander, D. E., Victor Insulators, Inc., Victor, N. Y.
Alexander, F. M., General Elec. Co., Schenectady, N. Y.
Alexander, L. A., F. C. Huyck & Sons, Albany, N. Y.
Ayres, R. W., Jr., General Elec. Co., Schenectady, N. Y.
Bailey, G. W., General Elec. Co., Syracuse, N. Y.
Barker, F. L., General Elec. Co., Schenectady, N. Y.
Bernzen, G. G., General Elec. Co., West Lynn, Mass.
Bickelhaupt, M. H., Jr., The Gleason Works, Rochester, N. Y.
Borgese, A. J., General Elec. Co., Pittsfield, Mass.
Chopra, A. K., Buffalo Niagara Elec. Corp., Buffalo, N. Y.
Crandall, W. M., Jr., Union Carbide & Carbon Corp., Niagara Falls, N. Y.
Crites, W. R., General Elec. Co., Schenectady, N. Y.
Dawson, A. W., Corning Glass Works, Corning, N. Y.
Dember, Howard J., New York Power & Light Corp., Albany, N. Y.
Dodson, G. C., Jr., General Elec. Co., Schenectady, N. Y.
Dranchak, M. A., General Elec. Co., Pittsfield, Mass.
Dumas, A. M., General Elec. Co., Pittsfield, Mass.
Emmons, R. C., Western Massachusetts Elec. Co., Springfield, Mass.
Feigenbaum, D. S., General Elec. Co., Pittsfield, Mass.
Fisk, D. A., General Elec. Co., Schenectady, N. Y.
Fletcher, T. C., General Elec. Co., West Lynn, Mass.
Fry, G. H., Jr., General Elec. Co., Schenectady, N. Y.
Gabbard, J. L., Jr., General Elec. Co., Pittsfield, Mass.
Gresham, W. S., General Elec. Co., Schenectady, N. Y.
Guimond, R. D., Foxboro Co., Foxboro, Mass.
Habermann, R., Jr., General Elec. Co., Pittsfield, Mass.
Hallgren, G. W., Cornell Univ., Ithaca, N. Y.
Helgeson, W. B., General Elec. Co., Bridgeport, Conn.
Jamison, J. T., General Elec. Co., Schenectady, N. Y.
Johnson, H. G., I-T-E Circuit Breaker Co., Boston, Mass.
Jones, R. E., General Elec. Co., Syracuse, N. Y.
Jones, R. W., Monitor Controller Co., Braintree, Mass.
Jonsson, N. G., Stone & Webster, Boston, Mass.
Judkis, M. H., General Elec. Co., Schenectady, N. Y.
Klemer, B. H., Sylvania Elec. Products Corp., Boston, Mass.
Krone, R. H., Jr., General Elec. Co., Schenectady, N. Y.
Lawton, E. H., Hartford Elec. Light Co., Hartford, Conn.
Limaye, R. P., 28 Putnam Ave., Cambridge, Mass.
Lisk, K. G., Eastman Kodak Co., Rochester, N. Y.
Magnusson, E. F., General Elec. Co., Pittsfield, Mass.
Maskalenko, E. J., Tufts College, Medford, Mass.
Matthews, J. A., I.B.M., Corp., Albany, N. Y.
Meisenheimer, R. L., General Elec. Co., Pittsfield, Mass.
Mercier, J. H., General Elec. Co., Schenectady, N. Y.
Midland, B., I.B.M. Corp., Boston, Mass.
Miller, R. W., American Steel & Wire Co., Worcester, Mass.
Mitchell, A. R., Jr., General Elec. Co., Lynn, Mass.
Moore, F. A., New York Tel. Co., Syracuse, N. Y.
Myers, B. S. (Student) Harvard Business School, Boston, Mass.
Newcomb, A. J., Jr., General Elec. Co., Schenectady, N. Y.
Oberbeck, G. A., NEGEA Service Corp., Cambridge, Mass.
Oleyar, M., Jr., Sperry Products Inc., Danbury, Conn.
Parish, W. J., American Brass Co., Torrington, Conn.
Patridge, R. F., General Elec. Co., Schenectady, N. Y.
Pike, D. B., Stone & Webster Engg. Corp., Boston, Mass.
Pullan, J. S., Board of Public Utilities, City of Jamestown, N. Y.
Quinn, R. J., Jr., The Monitor Controller Co., Boston, Mass.
Rees, F. X., General Railway Signal Co., Rochester, N. Y.
Rider, D. J., I.B.M. Corp., Endicott, N. Y.
Robinson, J. C., Jr., Exeter & Hampton Elec. Co., Exeter, N. H.
Rowe, A., General Elec. Co., Pittsfield, Mass.
Rowley, D. H., Union Carbide & Carbon Corp., Niagara Falls, N. Y.
Rubin, R., Andrew Alford, Consulting Engr., Boston, Mass.
Russell, L. T., Du Pont de Nemours & Co., Newburgh, N. Y.
Schamberger, J. M., Connecticut Light & Power Co., Greenwich, Conn.
Sensinger, W. A., Crouse-Hinds Co., Syracuse, N. Y.
Slater, C. F., Link Aviation, Inc., Binghamton, N. Y.
Steeper, D. E., General Elec. Co., Schenectady, N. Y.
Stephens, S. Q., Endicott Johnson Corp., Johnson City, N. Y.
Steyer, C. D., General Elec. Co., Lynn, Mass.
Stitt, R. P., Crouse-Hinds Co., Syracuse, N. Y.
Stott, R., Jr., Westinghouse Elec. Corp., Buffalo, N. Y.
Swanson, W. P., General Elec. Co., Schenectady, N. Y.
Thomas, E. M., N. Y. Tel. Co., Buffalo, N. Y.
Travis, F. B., General Elec., Schenectady, N. Y.
Vigoda, D. W., Jackson & Moreland, Boston, Mass.
Wahl, R. E., General Elec., Pittsfield, Mass.
Wall, E. T., Univ. of Maine, Orono, Maine
Watkins, J. R., Eastman Kodak Co., Kodak Park, Rochester, N. Y.
Wolfenson, J. I., General Elec. Co., Lynn, Mass.
Wong, S. Y., General Elec. Co., Pittsfield, Mass.
Zorio, L. F., Boston Edison Co., Boston, Mass.

2. Middle Eastern

Ackroyd, J. E., Jr., Public Service Elec. & Gas Co. of N. J., Camden, N. J.
Adams, J. I., The Pennsylvania Railroad Co., Philadelphia, Pa.
Ahearn, J. L., Jr., Naval Research Lab., Washington, D. C.
Allanson, O. L., Jr., Ohio Brass Co., Barberton, Ohio
Alouisa, F. B., Brown Instrument Co., Philadelphia, Pa.
Anderson, G. L., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Anderson, J. L., Jr., Chesapeake & Potomac Tel. Co. of Baltimore City, Baltimore, Md.
Baker, E. R., Jr., West Virginia Univ., Morgantown, W. Va.
Barclay, J. C., American Tel. & Tel. Co., Pittsburgh, Pa.
Beat, W. L., The Elec. Auto-Lite Co., Toledo, Ohio
Beck, C. E., General Elec. Co., Nela Park, E. Cleveland, Ohio
Bennett, L. C., Radio Station *WHKC*, Columbus, Ohio
Berger, F. L., Jr., Lewis Flight Propulsion Lab.-NACA, Cleveland, Ohio
Bermick, E. W., Maryland Drydock Co., Baltimore, Md.
Betts, D. C., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Bock, D., Black & Decker Mfg. Co., Towson, Md.
Bolesky, J. D., Therm-O-Disc Inc., Mansfield, Ohio
Booth, S. F., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Borst, R. L., The General Industries Co., Elyria, Ohio
Bowen, R. V., Cleveland Elec. Illuminating Co., Cleveland, Ohio
Brandle, E. M., Leeds & Northrup Co., Philadelphia, Pa.
Bright, R. C., Gilbert Assocs., Inc., Reading, Pa.
Brisky, R. W., Hertner Elec. Co., Cleveland, Ohio
Brown, E. O., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Brown, I., Sun Physical Lab., Newtown Square, Pa.
Brown, J. B., The Thomas Steel Co., Warren, Ohio
Brown, L. R., Radio Corp. of America, Washington, D. C.
Brutt, F. J., Westinghouse Elec. Co., E. Pittsburgh, Pa.
Carroll, J. E., Lincoln Elec. Co., Cleveland, Ohio
Chapin, S. L., Jr., Westinghouse Elec. Corp., Sharon, Pa.
Charlton, T., Westinghouse Elec. Corp., Lima, Ohio
Clark, W. J., Jr., Link-Belt Co., Philadelphia, Pa.
Clift, J. F., Westinghouse Elec. Co., E. Pittsburgh, Pa.
Coda, N., Erie Resistor Corp., Erie, Pa.
Coffman, R. E., Baugh Chemical Co., Baltimore, Md.
Colker, D. D., Dayton Power & Light Co., Dayton, Ohio
Coops, A. I., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Cottell, J. B., Bulldog Elec. Products, Cincinnati, Ohio
Cressman, R. F., Roller-Smith, Allentown, Pa.
Crews, J. C., Line Material Co., Zanesville, Ohio
Dailey, J. J., Jr., Reliance Elec. & Engg. Co., Cleveland, Ohio
Dana, G. M., Dayton Power & Light Co., Dayton, Ohio
Doeller, D. F., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Douglas, J. F., Rural Electrification Admin.; Washington, D. C.
Endres, J. M., Jr., General Industries, Inc., Philadelphia, Pa.
Esarey, R. W., Westinghouse Elec. Corp., Lima, Ohio
Evans, J. H., Jr., Bell Tel. Co. of Pennsylvania, Philadelphia, Pa.
Farrell, W. C., Jr., Chesapeake & Potomac Tel. Co. of Baltimore City, Baltimore, Md.
Feeley, A. G., Westinghouse Elec. Corp., Pittsburgh, Pa.
Fickle, L. E., Rural Electrification Admin., Washington, D. C.
Fogle, H. D., Jr., American Tel. & Tel. Co., Pittsburgh, Pa.
Fulda, F. W., Jr., Northern Pennsylvania Power Co., Towanda, Pa.
Furfari, C. H., Westinghouse Elec. Corp., Pittsburgh, Pa.
Gabuzda, L. R., Pennsylvania Power & Light Co., Hazleton, Pa.
Gadsden, C. M., General Elec. Co., Philadelphia, Pa.
Gates, J. G., Cincinnati Gas & Elec. Co., Cincinnati, Ohio
Gautier, E. H., Jr., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Gerrity, J. W., Natl. Carbon Co., Cleveland, Ohio
Giguette, G. B., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Giller, H. A., The Okonite Co., Philadelphia, Pa.
Gipe, A. B., Medical Division, Army Chemical Center, Md.
Gore, M. J., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Gorjanc, H. A., Cleveland Elec. Illuminating Co., Cleveland, Ohio
Gorman, H. J., Jr., Delaware Power & Light Co., Wilmington, Del.
Gourrich, G. E., Natl. Bureau of Standards, Washington, D. C.
Grace, C. H., Sound Systems, Inc., Cleveland, Ohio
Gray, J. A. C., The Maryland Drydock Co., Baltimore, Md.
Gray, R. C., The Maryland Drydock Co., Baltimore, Md.
Greene, J. C., Bendix Radio, Baltimore, Md.
Grund, J. B., Sylvania Elec. Prod. Inc., Emporium, Pa.
Hale, C. J., General Elec. Co., Erie, Pa.
Haley, C. C., Westinghouse Elec. Corp., Sharon, Pa.
Harker, H., Jr., Duquesne Light Co., Pittsburgh, Pa.
Harper, D. J., Republic Steel Corp., Massillon, Ohio
Harrison, H. R., General Elec. Co., Philadelphia, Pa.
Himes, D. E., The Ohio Power Co., Canton, Ohio
Hoffman, G. H., Consolidated Gas Elec. Light & Power Co., Baltimore, Md.
Holt, C. P., Westinghouse Elec. Corp., Baltimore, Md.
Janosky, F. R., Bell Tel. Co., of Pa., Pittsburgh, Pa.
Jeffers, W. W., Duquesne Light Co., Pittsburgh, Pa.
Jones, E. L., The Clark Controller Co., Cleveland, Ohio
Jones, J. R., Allis-Chalmers Mfg. Co., Pittsburgh, Pa.
Jones, R. R., Westinghouse Elec. Corp., Sharon, Pa.
Kain, J. M., Jr., General Elec. Co., Baltimore, Md.
Kemp, K. W., Rural Electrification Admin., Washington, D. C.
Ketterer, R. L., St. Joseph Lead Co. of Pennsylvania, Monaca, Pa.
Kirkpatrick, J. H., Jr., United Engineers & Constructors, Inc., Philadelphia, Pa.
Kleinpell, G. J., The Cleveland Elec. Illuminating Co., Cleveland, Ohio
Koval, E. R., Western Elec. Co., Allentown, Pa.
Kurpieski, S. A., West Penn. Power Co., Pittsburgh, Pa.
Lacke, P. E., Bethlehem Steel Co., Johnstown, Pa.
Landis, H. L., Gilbert Assocs., Inc., Reading, Pa.
Leap, W. A., Westinghouse Elec. Co., E. Pittsburgh, Pa.
Lefeber, R. G., I.T.E. Circuit Breaker Co., Philadelphia, Pa.
Leinbach, H. J., Jr., Natl. Bureau of Standards, Washington, D. C.
Linhart, R. H., Natl. Advisory Comm. for Aeronautics, Cleveland, Ohio
Logan, H. L., Bendix Aviation Corp., Baltimore, Md.
Long C. A., Westinghouse Elec. Corp., Sharon, Pa.
Lord, J., General Elec. Co., Erie, Pa.
Luppold, J. M., Carnegie Illinois Steel Corp., Dravosburg, Pa.
Lyons, G. V., Picker X-Ray Corp., Cleveland, Ohio
Marcus, T. J., Westinghouse Elec. Corp., Baltimore, Md.
Mason, E. A., General Elec. Co., Philadelphia, Pa.
Mathison, C. M., Superior Switchboard & Devices Co., Canton, Ohio
Matonak, L. P., Dravo Corp., South Heights, Pa.
McCreary, H. S., Jr., Westinghouse Elec. Corp., E. Pittsburgh, Pa.

McCullough, W. F., St. Joseph Lead Co., Monaca, Pa.
McKnight, R. E., Jr., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
McLaughlin, W. R., Picker X-Ray Corp., Cleveland, Ohio
McLennan, A. W., Toledo Edison Co., Toledo, Ohio
Meharg, E. F., The Lincoln Elec. Co., Cleveland, Ohio
Melden, M. G., Picker X-Ray Corp., Cleveland, Ohio
Meyer, R. C., Jr., Natl. Advisory Comm. for Aeronautics, Cleveland, Ohio
Mitchell, G. C., Jr., New York & Pennsylvania Co. Inc., Lock Haven, Pa.
Montplaisir, C. M., Line Material Co., E. Stroudsburg, Pa.
Morris, J. G., Maryland Drydock Co., Baltimore, Md.
Munson, W. A., Westinghouse Elec. Corp., Lima, Ohio
Musgrave, D. E., R. E. Uptegraff Mfg. Co., Scottdale, Pa.
Neal, F. C., Cincinnati Gas & Elec. Co., Cincinnati, Ohio
Oakes, H. J., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
O'Konski, W. B., Cleveland Elec. Illuminating Co., Cleveland, Ohio
Paul, W. M., Reliance Elec. & Engg., Cleveland, Ohio
Pawlechko, M. M., Reliance Elec. & Engg. Co., Cleveland, Ohio
Pehrson, J. H., Jr., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Petros, N. G., Bailey Meter Co., Pittsburgh, Pa.
Piccone, D. J., General Elec. Co., Philadelphia, Pa.
Pindell, W. Y., The Black & Decker Mfg. Co., Towson, Md.
Plagens, W. G., Picker X-Ray Corp., Cleveland, Ohio
Plevin, D., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Polonsky, J. M., Pennsylvania Power & Light Co., Allentown, Pa.
Quintin, W. P., Jr., Union Switch & Signal Co., Swissvale, Pa.
Reeves, J. H., Westinghouse Elec. Corp., Wilkes Barre, Pa.
Reinecke, B. E., Dept. of Army, Camp Detrick, Frederick, Md.
Rice, J. A., General Elec. Co., Erie, Pa.
Robinson, G. J., Philco Corp., Philadelphia, Pa.
Russel, B. G., Nat'l. Advisory Comm. for Aeronautics, Cleveland, Ohio
Russell, D. W., Westinghouse Elec. Corp., Lima, Ohio
Sargent, J. H., American Steel & Wire Co., Philadelphia, Pa.
Satin, N. J., Jr., Brown Instrument Co., Philadelphia, Pa.
Sauber, R. C., Toledo Scale Co., Toledo, Ohio
Schmid, J. A., Jr., Pennsylvania Power & Light Co., Allentown, Pa.
Schwab, P. E., Radio Corp. of America, Camden, N. J.
Sear, E. F., 16 Kingfisher Place, Audubon Village, N. J.
Seidel, R. B., Lincoln Elec. Co., Cleveland, Ohio
Sheehan, F. E., Emery Marker & Emery, Toledo, Ohio
Sims, C. E. (re-election), Ohio Power Co., Lima, Ohio
Smith, D. D., Pennsylvania State College, Alderson, Pa.
Smith, R. A., Toledo Edison Co., Toledo, Ohio
Spindler, F. E., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Staller, J. R. (re-election), Roller-Smith Division, Allentown, Pa.
Steele, M. G., Bendix Aviation Corp., Baltimore, Md.
Steinhoff, I. J., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Steward, H. R. (re-election), Pennsylvania Power & Light Co., Hazleton, Pa.
Stoddard, W. E., Sanderson & Porter Constructors, Monongahela, Pa.
Stouch, C. R., General Elec. Co., Charleston, W. Va.
Strosser, R. J. (re-election), Cleveland Elec. Ill. Co., Cleveland ,Ohio
Suttle, R. C., Reliance Elec. & Engg. Co., Cleveland, Ohio
Swasey, A. M., Jr., 5 E. Plumstead, Lansdowne, Pa.
Tatman, A., Hi-Voltage Equipment Co., Cleveland, Ohio
Taylor, H. W., Maryland Drydock Co., Baltimore, Md.
Thompson, T. F., Jr., Westinghouse Elec., E. Pittsburgh, Pa.
Truax, D. E., Allis-Chalmers Mfg., Co., Pittsburgh, Pa.
Underwood, J. F., Radio Corp. of America, Camden, N. J.
Valentine, F. B. (re-election), Westinghouse Elec. Corp., Lima, Ohio
Van Ravenswaay, R. C., United Engineers & Constructors, Inc., Philadelphia, Pa.
Voorhoeve, E. W., United Engineers & Constructors, Inc., Philadelphia, Pa.
Walker, R. C., Bucknell Univ., Lewisburg, Pa.
Waverchak, B. C., Cleveland Elec. Illuminating Co., Cleveland, Ohio
Webb, W. L., Bendix Aviation Corp.-Radio Div., Baltimore, Md.
Weiler, R. J., Natl. Advisory Comm. for Aeronautics, Cleveland, Ohio
Wier, W. E., Westinghouse Elec. Corp., Lima, Ohio
Williams, S. T., Reliance Electric & Engg. Co., Cleveland, Ohio
Willoughby, F. R., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Wilson, A. C. R., Black & Decker Mfg. Co., Towson, Md.
Winslow, D. E., Jr., Pennsylvania Transformer Co., Canonsburg, Pa.
Wooster, M. O., Rural Electrification Admin., Washington, D. C.
Wynne, J. J., Bendix Radio Co., Baltimore, Md.
Zahn, J. R., Reliance Elec. & Engg. Co., Cleveland, Ohio
Ziegler, N., Hernter Elec. Co., Cleveland, Ohio

3. New York City

Baer, T. M., Foster Wheeler Corp., New York, N. Y.
Barmby, A. R., Public Service Elec. & Gas Co., Newark, N. J.
Beckman, A., Remington Rand, New York, N. Y.
Bender, F. M., Weston Electrical Instrument Corp., Newark, N. J.
Blewitt, B. J., Public Service Elec. & Gas Co., Newark, N. J.
Bollettieri, P. J., N. Y. University College of Eng'r., New York, N. Y.
Budarf, P. P., Ebasco Services Inc., New York, N. Y.
Burzi, A. V. J., Morganite, Inc., Long Island City, N. Y.
Carberry, J. F., Western Union Tel. Co., New York, N. Y.
Clark, T. F., N. Y. Tel. Co., Hempstead, N. Y.
Conant, B. L. (Mrs.), 5 Nassau Place, East Orange, N. J.
Cooper, H. W., III, Airborne Instruments Lab., Mineola, N. Y.
Cruciani, G. V., N. Y. State Public Service Comm., New York, N. Y.
De Chiara, A. J., The Okonite Co., Passaic, N. J.
Deichert, R. W., Stevens Inst., Hoboken, N. J.
Elkes, R. H., Automatic Mfg. Corp., Newark, N. J.
Ernst, R. F., Cutler-Hammer, Inc., New York, N. Y.
Feldman, D. I., General Cable Corp., New York, N. Y.
Frost, E. L., General Elec. Co., Bellerose, N. Y.
Gruber, M. D., Ender Mfg. Corp., New York, N. Y.
Grussinger, H. W., The Austin Co., New York, N. Y.
Hagopian, G. A., Westchester Lighting Co., Mt. Vernon, N. Y.
Hamilton, W. H., Public Service Elec. & Gas Co., Newark, N. J.
Hausmann, H. C., Board of Transportation of the City of New York, N. Y.
Herson, M. J., Dept. of Water Supply, Gas & Elec., New York, N. Y.
Hontz, M. R., Public Service Elec. & Gas Co., Newark, N. J.
Horner, R. G., Cooper Union, New York, N. Y.
Kafalas, C., Sperry Gyroscope Co., Great Neck, N. Y.
Koudelka, O., Consolidated Edison Co., New York, N. Y.
Leibfried, T. F., Jr., John N. Fehlinger Co. Inc., New York, N. Y.
Lindenfelser, W. A., N. Y. Tel. Co., Brooklyn, N. Y.
Marcoux, H. P. J., Sperry Gyroscope Co., Lake Success, L. I., N. Y.
Massey, J. B., The Elec. Storage Battery Co., New York, N. Y.
Mayglothling, F. P., Dept. of Water Supply, Gas & Elec., New York, N. Y.
Nagel, J., Jr., New Jersey Bell Tel. Co., Asbury Park, N. J.
Neuman, I., Devenco, Inc., New York, N. Y.
November, G. S., Consolidated Edison Co., New York, N. Y.
Panagakos, A., Crocker-Wheeler, Ampere, N. J.
Paul, R. A., General Elec. Co., Bellmore, N. Y.
Peters, B. C. (Miss), General Elec. Co., Long Island City, N. Y.
Petrie, H. R., Public Service Elec. & Gas Co., Newark, N. J.
Pipkin, J. E., Sylvania Elec. Products Inc., Flushing, N. Y.
Pomper, A. W., John Waldron Corp., New Brunswick, N. J.
Ponnel, N., Board of Transportation of N. Y. C., New York, N. Y.
Preece, R. G., Fairchild Corp., Farmingdale, N. Y.
Radgowski, S. P., Consolidated Edison Co., New York, N. Y.
Ratcliff, J. N., Jr., Anaconda Wire & Cable Co., New York, N. Y.
Richman, P. L., Reeves Instrument Co., New York, N. Y.
Roseman, H. M., Squier Labs., Ft. Monmouth, N. J.
Roth, S. J., I.B.M., New York, N. Y.
Safir, R., Photovolt Corp., New York, N. Y.
Schafer, W. F., Crocker-Wheeler Elec. Mfg. Co., Ampere, N. J.
Schiller, H. H., Cooper Union, New York, N. Y.
Shapiro, H., Crocker Wheeler Elec. Mfg. Co., Ampere, N. J.
Sherman, L., U. S. Air Force, APO 856, c/o P.M., New York, N. Y.
Sherman, S., Arma Corp., Brooklyn, N. Y.
Shneyer, W., 945 Eastern Parkway, Brooklyn, N. Y.
Smith, R. H., Federal Tel. & Radio Corp., Clifton, N. J.
Stephanz, K. R., Federal Tel. & Radio, Clifton, N. J.
Taggi, A. J., American Tel. & Tel. Co., New York, N. Y.
Walch, J. M. D., Public Service Gas & Elec. Co., Newark, N. J.
Waterman, M. N., Westinghouse Elec. Corp., Bloomfield, N. J.
Yokelson, B. J., Bell Tel. Labs. Inc., New York, N. Y.

4. Southern

Baker, R. W., Georgia Power Co., Atlanta, Ga.
Bowers, W. G., Carolina Power & Light Co., Asheville, N. C.
Burkhalter, L. C., Gulf States Utilities Co., Baton Rouge, La.
Cantor, C., T.V.A., Knoxville, Tenn.
Clark, A. D., Georgia Power Co., Atlanta, Ga.
Cooke, H. F., U. S. Dept. of Agriculture, Stoneville, Miss.
Covington, C. L., Western Union Tel. Co., New Orleans, La.
Darsey, R. C., Southern Bell Tel. & Tel. Co., Columbia, S. C.
Daugherty, J. D., Florida Public Utilities Co., Fernandina, Fla.
Foster, H. E. (Student), Univ. of North Carolina, Raleigh, N. C.
Freeman, J. D., Jr., Freeman's Elec. Co., Tuscaloosa, Ala.
Gary, W. E., Carbide & Carbon Chemicals Corp., Oak Ridge, Tenn.
Graham, L. R., Southern Bell Tel. & Tel. Co., Atlanta, Ga.
Griffith, R. S., General Elec. Co., Atlanta, Ga.
Haile, R. H., III, R. H. Haile Elec. Co., Columbia, S. C.
Hand, E. W., Carbide & Carbon Chemical Corp., Oak Ridge, Tenn.
Harris, C. X., T.V.A., Chattanooga, Tenn.
Henagan, C. S., Jr., Southern Bell Tel. Co., Birmingham, Ala.
Heyman, L. H., Memphis Light Gas & Water Div., Memphis, Tenn.
Hurt, A. B., Jr., North Carolina State College, Raleigh, N. C.
James, A. H., Mississippi Power & Light Co., Vicksburg, Miss.
Keeler, R. J., Virginia Polytechnic Inst., Blacksburg, Va.
Koslow, H. M., Engineer Research & Development Labs., Ft. Belvoir, Va.
Latimer, H. A., Chesapeake & Potomac Tel. Co. of Va., Richmond, Va.
Meyer, R. J., Louisiana Power & Light Co., Gretna, La.
Nelson, J. M., Jr., Dept. of Army, Corps of Engrs., Savannah, Ga.
Neville, S. L., Jr., T.V.A., Chattanooga, Tenn.
O'Brien, J. G., T.V.A., Watts Bar Dam, Tenn.
Ownbey, E. H., T.V.A., Chattanooga, Tenn.
Pankonien, J. M., 2nd Lt. Cavalry, U. S. Army, Ft. Knox, Ky.
Pearsall, S. H., Jr., W S M , Inc., Nashville, Tenn.
Peyton, W. R., Kentucky & West Virginia Power Co. Inc., Hazard, Ky.
Potts, J. F., Jr., T.V.A., Chattanooga, Tenn.
Roark, W. L., Jr., Avondale Mills, Sylacauga, Ala.
Scott, D. H., Jr., Virginia Elec. & Power Co., South Boston, Va.
Smith, G. A., T.V.A., Cleveland, Tenn.
Steppe, J. T., Jr., South Carolina Elec. & Gas Co., Columbia, S. C.
Stevenson, M. W., Western Union Tel. Co., Atlanta, Ga.
Stilwell, R. N., W. C. Teas Co., Chattanooga, Tenn.
Street, J. M., Jr., Southern Bell Tel. & Tel. Co., Birmingham, Ala.
Teeple, R. P., Southern Bell Tel. & Tel. Co., Inc., Atlanta, Ga.
Wadsworth, E. T., Jr., T.V.A., Chattanooga, Tenn.
Walton, J. A., Southern Bell Tel. & Tel., Atlanta, Ga.
Ward, J. W., Avondale Mills, Sylacauga, Ala.
Welch, R. D., Tampa Elec. Co., Tampa, Fla.
White, G. K., Florida Power & Light Co., Ft. Lauderdale, Fla.

5. Great Lakes

Allender, C. L., Iowa State College, Ames, Iowa
Allison, O., Illinois Bell Tel. Co., Chicago, Ill.
Alt, J. R., Square D. Co., Detroit, Mich.
Anderson, V. A., Consumers Power Co., Jackson, Mich.
Baebler, A. W., Illinois Northern Utilities Co., Dixon, Ill.
Baldini, E. A., Detroit Edison Co., Detroit, Mich.
Barber, P. D., Graybar Elec. Co., Duluth, Minn.
Barker, F. D., Western Union Tel. Co., Chicago, Ill.
Battau, W. O., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bender, J. S., Wisconsin Elec. Power Co., Milwaukee, Wis.
Blicher, H. M., Commonwealth & Southern Corp., Jackson, Mich.
Bredvik, M., Kaiser Frazer Corp., Willow Run, Mich.
Brower, H. P., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Brown, R. E., Commonwealth Edison Co., Chicago, Ill.
Bruce, M. H., Commonwealth Elec. Co., St. Paul, Minn.
Burandt, R. P., Rose Polytechnic Inst., Terre Haute, Ind.
Burns, R. M., Commonwealth Edison Co., Chicago, Ill.
Carter, D. C., The Wilsons, Lafayette, Ind.
Decker, R. L., Standard Oil (Ind.), Whiting, Ind.
Donnell, R. M., General Elec. Co., Ft. Wayne, Ind.
Doocy, E. S., Laramore & Douglass, Inc., Engrs., Paxton, Ill.
Enderle, C. N., Northern Ordnance, Inc., Minneapolis, Minn.
Erickson, H., Western Union Tel. Co., Minneapolis, Minn.
Fairman, R. N., North Dakota State College, Fargo, N. Dak.
Featham, A. E., The Detroit Edison Co., Detroit, Mich.
Ferk, L. A., Cutler-Hammer, Inc., Milwaukee, Wis.
Fleissner, J. M., Wisconsin Elec. Power Co., Milwaukee, Wis.
Foltz, R. P., Illinois Bell Tel. Co., Chicago, Ill.
Fox, J. O., Louis Allis Co., Milwaukee, Wis.
Funk, J. R., Joslyn Mfg. & Supply Co., St. Paul, Minn.
Gerler, K. E., Illinois Bell Tel. Co., Chicago, Ill.
Goulding, W. L., Jr., Chevrolet-Detroit Forge, Detroit, Mich.
Grace, J. W., American Tel. & Tel. Co., Chicago, Ill.
Grasser, W. E., Central Illinois Elec. & Gas Co., Rockford, Ill.
Gribble, J. J., Square D Co., Milwaukee, Wis.
Grigsby, J. L., Iowa State College, Ames, Iowa
Hall, F. B., Rowe Engg. Corp., Chicago, Ill.
Harger, W. W., Farnsworth Television & Radio Corp., Ft. Wayne, Ind.
Harmon, D., Western Union Tel. Co., Minneapolis, Minn.
Harner, E. M., Commonwealth & Southern Corp., Jackson, Mich.
Hathaway, W. F., Consumers Power Co., Flint, Mich.
Hiatt, W. C., American Tel. & Tel. Co., Indianapolis, Ind.
Hineline, W. H., Chicago Dist. Elec. Generating Corp., Hammond, Ind.
Houtsma, J. H., General Elec. Co., Detroit, Mich.
Hunter, B. B., The Commonwealth & Southern Corp., Jackson, Mich.
Jontz, W. M., Purdue Univ., Lafayette, Ind.

Kalsow, K., Commonwealth & Southern Corp., Jackson, Mich.
Krausse, S. C., Jr., General Motors, Milford, Mich.
Kulawinski, C. R., Northern Indiana Public Service Co., Michigan City, Ind.
Kuzela, L. J., Western Union Tel. Co., Minneapolis, Minn.
Laube, C. E., 4446 South 27 Street, Milwaukee, Wis.
Lawall, P. K., Indianapolis Power & Light Co., Indianapolis, Ind.
Leitz, E. C., Spaulding Fibre Co., Ft. Wayne, Ind.
Lippert, W. O., General Elec. Co., Chicago, Ill.
MacDonald, J. W., Fairbanks, Morse & Co., Detroit, Mich.
Martin, R. P., Carnegie Illinois Steel Corp., Chicago, Ill.
Matsumoto, T., Laramore & Douglass, Inc., Chicago, Ill.
McAdow, R. N., Shell Oil Co., Inc., Wood River, Ill.
McClintock, D. C., Sargent & Lundy, Chicago, Ill.
Mitchell, D. C., Detroit Edison Co., Detroit, Mich.
Montoya, E., Jr., Indiana Technical College, Ft. Wayne, Ind.
Montross, R. C., Square D Co., Milwaukee, Wis.
Murray, L. F., Consumers Power Co., Jackson, Mich.
Nasser, M., General Elec. Co., Ft. Wayne, Ind.
Palin, W. H., Cutler-Hammer, Inc., Milwaukee, Wis.
Partridge, G. F., American Wheelabrator & Equipment Corp., Mishawaka, Ind.
Pomon, J.D., American Phenolic Corp., Chicago, Ill.
Quell, B. S., Michigan Bell Tel. Co., Detroit, Mich.
Reeder, G. S., Public Service Co. of Northern Illinois, Chicago, Ill.
Reid, W. L., Consumers Power Co., Jackson, Mich.
Renish, K. J., Allen-Bradley Co., Milwaukee, Wis.
Ries, R. G., Square D. Co., Milwaukee, Wis.
Roche, J. B., Public Service Co. of Northern Illinois, Chicago, Ill.
Rockenbach, V. O., Westinghouse Elec. Corp., Chicago, Ill.
Roe, R. K., Kaiser-Frazer Corp., Willow Run, Mich.
Ross, H. C., Halliburton Oil Well Cementing Co., Fairfield, Ill.
Schaller, T. L., Allen-Bradley Co., Milwaukee, Wis.
Schnakenburg, R. H., Southern Indiana Gas & Elec. Co., Evansville, Ind.
Seid, H. R., Commonwealth & Southern Corp., Jackson, Mich.
Simson, V. H., Cutler-Hammer, Inc., Milwaukee, Wis.
Skaggs, W. A., Commonwealth & Southern Corp., Jackson, Mich.
Sladek, O. C., Western Elec. Co., Chicago, Ill.
Smith, M. I., Wisconsin Power & Light Co., Baraboo, Wis.
Sommers, W. A., Standard Oil Co. (Indiana), Whiting, Ind.
Spiece, S. J., Stearns Magnetic Co., Milwaukee, Wis.
Stettner, R. F., Western United Gas & Elec. Co., Aurora, Ill.
Stinchcomb, W. B., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Stolarski, E. H., Commonwealth & Southern Corp., Jackson, Mich.
Strong, J. M., General Elec. Co., Ft. Wayne, Ind.
Sullivan, J. B., Iowa Power & Light Co., Des Moines, Iowa
Szpak, E. Z., Giffels & Vallet Inc., Detroit, Mich.
Taylor, L. D., Vickers Inc., Detroit, Mich.
Tewksbury, R. A., Duncan Elec. Mfg., Co., Lafayette, Ind.
Thome, R. E., Square D Co., Detroit, Mich.
Thompson, D. M., I.B.M. Corp., Des Moines, Iowa
Tunstall, D. P., Commonwealth Edison Co., Chicago, Ill.
Vick, H. J., Jr., Univ. of Wisconsin, Madison, Wis.
Wahlen, D. J., 2135 North 40th St. Milwaukee, Wis.
Waisanen, W. F. (re-election), Smith, Hinchman & Grylls, Detroit, Mich.
Walsh, R. G., Roberts & Scheafer, Chicago, Ill.
Weitekamp, M. E., Louis Allis Co., Milwaukee, Wis.
Wilkins, S. B., General Elec. Co., Ft. Wayne, Ind.
Wolf, R. W., Standard Oil Co., (Indiana), Chicago, Ill.
Wray, W. J., Jr., Ford Motor Co., Dearborn, Mich.
Yared, J., 204 Vivian St., Houghton, Mich.

6. North Central

Coellen, W. F., Denver Tramway Corp., Denver, Colo.
Gunther, C. E., Univ. of Colorado, Boulder, Colo.
Hayden, J.R., Public Service Co. of Colo., Denver, Colo.
Loeber, J. A., Omaha Public Power District, Omaha, Nebr.
Meyers, J. L., Omaha Public Power District, Omaha, Nebr.
Owen, W. H., Bureau of Reclamation, Paonia, Colo.
Rose, C. L., U. S. Bureau of Reclamation, Denver, Colo.
Sinovich, J., Evans Elec. Constr. Co., Omaha, Nebr.
Smith, R. E. (Student), Colo. A. & M. College, Manitou Springs, Colo.
Stearns, M. H., Bureau of Reclamation, Denver, Colo.
Walker, H. W., Leo A. Daly Co., Omaha, Nebr.
Williams, S. K., South Dakota School of Mines & Tech., Rapid City, S. Dak.
Wolfe, D. F., 3024 Dudley St., Lincoln, Nebr.

7. South West

Adams, C. D., Jr., Honeywell Regulator Co., Houston, Tex.
Beitch, E., S. C. Sachs Co., Inc., St. Louis, Mo.
Bennett, W. J., Southwestern Gas & Elec. Co., Marshall, Tex.
Berkemeyer, Richard, W., Century Elec. Co., St. Louis, Mo.
Bollen, W. A., Jr., Arkansas Power & Light Co., El Dorado, Ark.
Botzong, W. B., Phillips Oil Co., Alvin, Tex.
Bragg, R. E., General Elec. Supply Corp., Little Rock, Ark.
Brockhouse, W. J., Jr., J. E. Murray & Co., Kansas City, Mo.
Brown, G. L., Research Foundation, Oklahoma A. & M. College, Stillwater, Okla.
Casella, J., U. S. Army, Corps. of Engrs., Dallas, Tex.
Chase, G. D., Southwestern Public Service Co., Plainview, Tex.
Clark, W. C., Stanolind Pipe Line Co., Tulsa, Okla.
Cockrell, F. M., Phillips Petroleum Co., Phillips, Tex.
Cook, M. W., Shell Oil Co., Inc., Houston, Tex.
Cox, W. G., Public Service Co. of Okla., Tulsa, Okla.
Crossman, R. N., Jr., Houston Lighting & Power Co., Houston, Tex.
Dorman, K., Southwestern Bell Tel. Co., El Reno, Okla.
Dotts, T. J., Southwestern Public Service Co., Lubbock, Tex.
Dulin, E. R., Southwestern Bell Tel. Co., Dallas, Tex.
Emo, R. E., Century Elec. Co., St. Louis, Mo.
Fincher, N. E., Humble Oil & Refining Co., Avoca, Tex.
Fisher, L. L., New Mexico School of Mines, Albuquerque, N. Mex.
Folan, W., Oklahoma A. & M. College, Stillwater, Okla.
Freiberger, H. A., Texas Elec. Service Co., Big Spring, Tex.
Gove, R. L., Swift & Co., So. St. Joseph, Mo.
Harp, C. E., Univ. of Oklahoma, Norman, Okla.
Haynes, W. H., Arkansas Power & Light Co., El Dorado, Ark.
Hessemer, R. A., Jr., Univ. of New Mexico, Albuquerque, N. Mex.
Honaker, C. M., Community Public Service Co., Pecos, Tex.
House, F. F., Crouse-Hinds Co., Houston, Tex.
Inclan, E. L. (re-election), Mexican Light & Power Co. Mexico City, Mexico
Ingram, C. B., General Tire & Rubber Co., Waco, Tex.
Johnston, C. E., Jr., Box 1715, Fayetteville, Ark.
Jones, F. W., Texas Utilities Co., Abilene, Tex.
Knowles, I., Texas Elec. Service Co., Ft. Worth, Tex.
Lawson, V. R., Frank Horton & Co., Lamar, Mo.
Leavitt, S. A., American Smelting & Refining Co. Chihuahua, Chihuahua, Mexico
Miller, J. R., Kansas City Power & Light Co., Kansas City, Mo.
Miller, N. D., Geophysical Service Inc., Dallas, Tex.
Moore, J. R., Jr., Texas Power & Light Co., Waco, Tex.
Moisier, R. L., Jr., Corps of Engineers, Tulsa, Okla.
Noel, C. A., Oklahoma A. & M. College, Stillwater, Okla.
Owens, R. R., Harding Glass Co., Fort Smith, Ark.
Parsons, D. A., Texas Power & Light Co., Waco, Tex.
Pierson, A. L., III, 619 West Alabama Ave., Houston, Tex.
Raymond, W. W., El Paso Elec. Co., El Paso, Tex.
Riley, J. W., Southwestern Bell Tel. Co., Kansas City, Mo.
Rockefeller, G. D., Jr., U. S. Army, White Sands Proving Grounds, Las Cruces, N. Mex.
Rusk, J. H., Pittsburgh Plate Glass Co., Crystal City, Mo.
Rutherford, W. T., Los Alamos Scientific Labs., Sandia Base, Albuquerque, N. Mex.
Sachs, L. S., S. C. Sachs Co., Inc., St. Louis, Mo.
Salter, T. J., Jr., Sinclair Prairie Oil Co., Tulsa, Okla.
Shoup, J. R., Wagner Elec. Corp., St. Louis, Mo.
Spencer, W. E., Southwestern Bell Tel. Co., Kansas City, Mo.
Stuckey, K. L., Black & Veatch, Kansas City, Mo.
Taylor, R. G., Bussmann Mfg. Co., St. Louis, Mo.
Tysinger, J. W., Shell Oil Co., Wichita Falls, Tex.
Wadkins, O. L., Jr., U. S. Army, White Sands Proving Ground, Las Cruces, N. Mex.
Weaver, J. A., Sohio Pipe Line Co., St. Louis, Mo.
Weiss, J. D., Electrical & Mechanical Supply Co., Ind., El Paso, Tex.
West, R. B., Stanolind Oil & Gas Co., Tulsa, Okla.
Wilson, A. C., Stanolind Oil & Gas Co., Plainview, Tex.
Wilson, B. A., Texas Technological College, Lubbock, Tex.
Wilson, I. L., Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Young, P. D., Wagner Elec. Corp., St. Louis, Mo.

8. Pacific

Bayley, R. M., Dept. of Water & Power, Los Angeles, Calif.
Bliklen, P. F., Rt. 7, Box 1182, Phoenix, Ariz.
Bower, F. U., 1508 West 28th St., Los Angeles, Calif.
Crowley, C. P., Control Corp., Los Angeles, Calif.
Devine, J., Westinghouse Elec. Corp., Phoenix, Ariz.
Finlay, E. G., Pacific Gas & Elec. Co., Emeryville, Calif.
Freeman, J. R., Jr., Univ. of California, Oakland, Calif.
Frost, A. M., Douglas Aircraft Co., Inc., Santa Monica, Calif.
Fuller, J. K., Colorado Central Power Co., Englewood, Calif.
Gillanders, J. R., Pacific Gas & Elec. Co., Oakland, Calif.
Gold, S. H., California Elec. Power Co., Riverside, Calif.
Hanson, E. A., 15874 Via Paro, San Lorenzo, Calif.
Harman, W. A., North American Aviation, Inc. Downey, Calif.
Hudson, H. F., Salt River Valley Water Users Assn., Phoeniz, Ariz.
Jeschke, A. W., Elcon Mfg. Co., Los Angeles, Calif.
Keesler, D., North American Aviation, Inc., Downey, Calif.
Langdon, J. G., Northrop Aircraft, Inc., Hawthorne, Calif.
McLean, A. L., Pacific Gas & Elec. Co., Willits, Calif.
Parker, C. E., San Francisco Naval Shipyard, San Francisco, Calif.
Porter, O. C., The Pacific Tel. & Tel. Co., San Francisco, Calif.
Roach, B. I., Jr., Standard Oil Co. of California, Richmond, Calif.
Rosenberg, J. M., RCA Service Co., San Francisco, Calif.
Seaward, P. E., U. S. Naval Electronics Lab., San Diego, Calif.
Somers, J. W., Pacific Gas & Elec. Co., San Francisco, Calif.
Sutter, B. M. (re-election), Pacific Gas & Elec. Co. San Francisco, Calif.
Test, A. J., Univ. of Calif., Berkeley, Calif.
Tipper, E. R., Pacific Gas & Elec. Co., Napa, Calif.

9. North West

Bennett, E. E., Boeing Airplane Co., Seattle, Wash.
Craine, L. B., Oregon State College, Corvallis, Oreg.
Crosetti, L. P., U. S. Bureau of Reclamation, Columbia Falls, Mont.
Dietrich, R. E., Bonneville Power Admin., Portland, Oreg.
Gilchrist, N. A., Bonneville Power Adm., Walla Walla, Wash.
Groberg, L. R., Puget Sound Power & Light Co., Bremerton, Wash.
Hall, E. T., Line Material Co., Salt Lake City, Utah
Harlow, F. J., Bunker Hill & Sullivan Mining & Concn. Co., Kellogg, Idaho
Hart, C. E., Bonneville Power Admin., Portland, Oreg.
Holland, R. M., Bonneville Power Adm., Tacoma, Wash.
Kurtz, L. W., Jr., Portland General Elec. Co., Portland, Oreg.
Langlois, C. A., Reynolds Metals Co., Troutdale, Oreg.
Lee, R. M., Portland General Elec. Co., Portland, Oreg.
Luck, R., Bonneville Power Admin., Portland, Oreg.
O'Hearon, J. B., Puget Sound Power & Light Co., Seattle, Wash.
Rea, D., Seattle City Light, Seattle, Wash.
Southworth, R. W., Seneca, Oreg.
Stampalia, I. J., Jr., Boeing Airplane Co., Seattle, Wash.
Sterba, W. W., Bonneville Power Admin., Portland, Oreg.
Thompson, B. W., General Elec. Co., Richland, Wash.
Wilson, J. W., Bureau of Reclamation, Ephrata, Wash.
Wright, E. T., Jr., U. S. Engr. Dept., Portland, Oreg.

10. Canada

Ambuhl, F., Jr., Supreme Power Supplies Ltd., Mimico, Ontario, Canada
Armstrong, J. A., English Elec. Co. of Canada, St. Catharines, Ontario, Canada
Ball, H. T., Consolidated Paper Corp. Ltd., Three Rivers, Quebec, Canada
Bartlet, A. W., Northern Elec. Co. Ltd., Montreal, Quebec, Canada
Cheney, W. K., Bell Tel. Co. of Canada, Toronto, Ontario, Canada
Davis, E. T., Canadian Westinghouse Co., Ltd., Hamilton, Ontario, Canada
Eagle, M., Canadian General Elec. Co., Paterboro, Ontario, Canada
Forrest, W. G., North American Cyanamid Ltd., Niagara Falls, Ontario, Canada
Francis, W. E., Bell Tel. Co., Toronto, Ontario, Canada
Hall, C. D., Bepco Canada Limited, Montreal, Quebec, Canada
Hermeston, R., Hydro-Elec. Power Comm. of Ont., Toronto, Ontario, Canada
Jeffrey, D. B., Maclaren Quebec Power Co., Buckingham, Quebec, Canada
Joe, H. C. L., English Elec. Co. of Canada, Ltd., St. Catharines, Ontario, Canada
Kaliski, T., Power Corp. of Canada Ltd., Montreal, Quebec, Canada
Lax, P. E., Hydro-Elec. Power Comm., of Ont., Toronto, Ontario, Canada
MacLean, R. J., Aluminum Co. of Canada, Ltd., Shawinigan Falls, Quebec, Canada
McTaggart, D. J., Toronto Hydro Elec. System, Toronto, Ontario, Canada
Moore, W. J. M., National Research Council, Ottawa, Ontario, Canada
Northover, A. C., Midland Public Utilities Comm. Midland, Ontario, Canada
Packham, J. L., Canadian General Elec. Co., Peterborough, Ontario, Canada
Ridout, J. S., Hydro Elec. Power Comm. of Ont. Toronto, Ontario, Canada
Smith, D. L., Ontario Hydro-Elec. Power Comm. Glasgow Station, Ontario, Canada
Thorsley, L. L., Canadian Westinghouse Co., Hamilton Ontario, Canada
Westwood, R. E., Hydro-Elec. Power Comm. of Ont. Toronto, Ontario, Canada

Elsewhere

Bigelman, J., Cuban Tel. Co., Havana, Cuba
Branstetter, H. D., Creole Petroleum Corp., Caripito Monagas, Venezuela, South America
Breaden, M. L., A. Reyrolle & Co., Ltd., Hebburn-on-Tyne, Co. Durham, England
Calderon, V. A. B., Braden Copper Co., Rancagua, Chile, South America
Chaudhary, B. D., 1204/23 Shivajinagar, Poona, India
Corcoran, W. P., Energia Electrica da Bahia, Bahia, Brazil, South America
Das Gupta, M. S., Military Engg. Services India, Panagarh, Dist. Burdwan, West Bengal, India
Foster, W. G., Pearl Harbor Naval Shipyard, Honolulu, Territory of Hawaii
Jain, M. L., British Motors, Ambala, India
Kapoor, D. N., Central Power House, Dalmianager, Bihar, India
Petrashuyk, P., C. A. Energia Electrica de Venezuela, Maracaibo, Venezuela, South America
Slochowski, I. M., Factoria Canepa-Tabini, Lima, Peru, South America
Wilson, I. F. D., A. Reyrolle & Co., Ltd., Hebburn-on-Tyne, England

Total to grade of Associate

United States, Canada, and Mexico, 627
Elsewhere, 13

OF CURRENT INTEREST

Seminar Is Held to Discuss Disposal of Radioactive Waste

Leading members of the sanitary and waterworks engineering professions met in Washington, D. C., during the last week in January to attend a seminar on the disposal of radioactive wastes. This seminar, held by the United States Atomic Energy Commission, is part of the continuing effort on the part of the government to maintain close liaison with public health and safety officials on mutual problems arising out of the national atomic energy program.

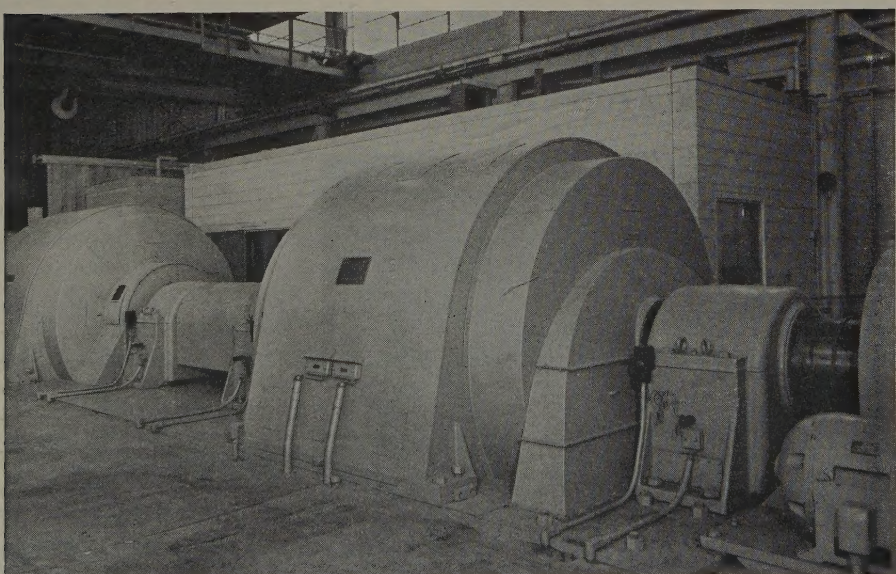
In his introductory remarks, chairman of the commission, David E. Lilienthal, pointed out that "handling the waste disposal problem is part of learning how to live with radiation. The way we have learned to live with unfamiliar things before was to learn as much as we could about them; not to get overly emotional or hysterical."

Among the topics discussed in the remarks of subsequent speakers, and in the informal discussion periods, were the types of activities in the national atomic energy program leading to the production of atomic wastes; the effects, controls, tolerances, and methods of measuring radioactivity; the production, distribution, use, and controls of radioisotopes; health problems in atomic energy activities; current methods for disposing of gaseous, liquid, and solid radioactive wastes; and an appraisal of sanitary engineering problems in the atomic energy industry.

Experts from the Atomic Energy Commission technical staff, the Argonne National Laboratory at Chicago, the Oak Ridge National Laboratory, and other institutions doing atomic and radioactive research conducted various sections of the seminar and contributed technical data for the use of those attending.

Participants were selected from the American Water Works Association, Federation of Sewage Works Associations, Conference of State Sanitary Engineers, and Conference of Municipal Sanitary Engineers. Co-operating government agencies included the Public Health Service, Geological Survey, the Weather Bureau, Tennessee Valley Authority, Office of the Secretary of Defense, and Department of the Navy. Abstracts of talks and discussion may be obtained from: Public Information Branch, Atomic Energy Commission, 19th and Constitution, N. W., Washington, D. C.

Supersonic Wind Tunnel Drive



The world's largest supersonic wind tunnel, capable of producing winds of about 1,500 miles per hour, is now in use in Cleveland, Ohio, following development by the National Advisory Committee for Aeronautics. Wind is created by the air compressor which is driven by three 29,000-horsepower electric motors hooked in tandem to a single drive shaft. The motors, which operate at 900 revolutions per minute, are the largest ever built to run at that speed. Their 87,000-horsepower total is the greatest ever used in a wind tunnel installation. Designed and built by General Electric, the motors are wound-rotor 8-pole 6,600-volt induction motors using 3-phase 60-cycle power from standard lines

Low Temperature Lab Built at Schenectady

Temperatures of 459 degrees below zero Fahrenheit will be commonplace in a new $250,000 low-temperature laboratory just completed by the General Electric Research Laboratory at Schenectady, N. Y. The low-temperature laboratory is one part of the new G-E Research Laboratory nearing completion at Knolls, near Schenectady. The unique building will be devoted entirely to research at temperatures close to absolute zero. This research is part of continuing work which seeks to find out more about the behavior of matter at low temperatures. This knowledge in turn may give insight into the behavior of matter at all temperatures.

The building is 60 by 70 feet over-all. Half of the space is taken up by two huge liquefying plants, where liquid helium and hydrogen will be made for use in experiments. The plant is expected to produce about seven gallons of liquid hydrogen and two gallons of liquid helium in an hour. The remainder of the building is given over to laboratories for experiments, large electric generators to run electromagnets for magnetic studies at low temperatures, and a machine shop for maintenance work on the liquefiers.

The laboratory is especially designed to provide maximum safety in work with hydrogen, which is explosive when mixed with certain other gases. Heavy shields separate personnel from the liquefying machinery and stored hydrogen. The building's outer walls are made up largely of windows, which would relieve any pressures in the remote event of an explosion.

Doctor Reissner Honored. One of the great pioneers of aviation, Doctor Hans J. Reissner, who has made important contributions to aeronautics since the time Wilbur Wright first flew in Europe and who has made equally significant contributions to civil engineering and applied mechanics for the past 50 years, was honored by leading scientists in applied mechanics and aeronautical engineering on the occasion of his 75th birthday at a dinner at the Fifth Avenue Hotel, New York, N. Y., Tuesday, January 18, 1949. Doctor Reissner, now professor of aerodynamics and aerostructures at the Polytechnic Institute of Brooklyn, designed the first all metal airplane to fly in 1912 and the first controllable pitch propeller during World War I. Presently he is in the forefront of research on the most modern propulsion devices for the Office of Naval Research of the United States Navy and the National Advisory Committee for Aeronautics on the secrets of supersonic aeronautics. A Reissner Anniversary Volume, an important new addition to the literature of the field of applied mechanics, was prepared for presentation at the dinner. The volume contains 32 contributions by leading authorities in the United States, England, France, Germany, Sweden, Norway, and Yugoslavia.

Tentative Program Set for Corrosion Conference

Titles of 41 of the 42 technical papers scheduled to be delivered at the 1949 conference of the National Association of Corrosion Engineers have been tentatively announced by Doctor N. E. Berry, Servel, Inc., Evansville, Ind., chairman of the technical program committee. The conference is to be held April 11–14 in Cincinnati, Ohio. A. B. Campbell, executive secretary, at the central NACE office in Houston said only minor changes in the program may be expected now.

The papers, prepared by men recognized as authorities in their respective fields, will be given at 11 symposia: corrosion principles, chemical industry, electrical and communications industries, cathodic protection, pulp and paper industry, general industry, transportation industry, protective coatings, oil industry, salt water corrosion, gas industry. Full program details and a list of the papers may be obtained from National Association of Corrosion Engineers Headquarters, 905 Southern Standard Building, Houston, Tex.

Future Meetings of Other Societies

American Chemical Society. Semiannual meeting. March 28–April 1, 1949, San Francisco, Calif.

American Society of Chemical Engineers. Los Angeles, Calif., regional meeting, March 6–9, 1949; Tulsa, Okla., regional meeting, April 8–12, 1949.

American Management Association. Production meeting. April 14–15, 1949, Hotel Statler, New York, N. Y.

American Society of Civil Engineers. Spring meeting. April 20–23, 1949, Oklahoma City, Okla.

American Society of Mechanical Engineers. 1949 Spring meeting. May 2–4, 1949; New London, Conn.

American Society for Metals. 6th Western Metal Congress and Exhibition. April 11–16, 1949, Shrine Auditorium, Los Angeles, Calif.

American Society of Tool Engineers. 17th annual meeting. March 10–12, 1949, Hotel William Penn, Pittsburgh, Pa.

Chicago Production Show. Chicago Technical Societies Council. March 14–17, 1949, Hotel Stevens, Chicago, Ill.

Conference for Protective Relay Engineers. March 14–16, 1949, Texas A & M College, College Station, Texas.

Electrochemical Society. Spring meeting. May 4–7, 1949, Benjamin Franklin Hotel, Philadelphia, Pa.

Engineers Council of Houston. Second Annual Symposium. April 2, 1949, Rice Hotel, Houston, Texas.

Hydraulic Institute. March 20–22, 1949, The Drake, Chicago, Ill.

Institute of Radio Engineers. 1949 annual convention. March 7–10, 1949, Hotel Commodore and Grand Central Palace, New York, N. Y.

Institute of Radio Engineers-Radio Manufacturers Association. Fourth annual Spring meeting. April 25–27, 1949, Benjamin Franklin Hotel, Philadelphia, Pa.

Instrument Society of America. Fourth annual Spring meeting. May 12–13, 1949, Royal York Hotel, Toronto, Ontario, Canada.

Michigan Safety Conference. 19th annual meeting May 17–20, 1949, Hotels Leland, Shelby, and Book-Cadillac, Detroit, Mich.

Midwest Power Conference. April 18–20, 1949, Sherman Hotel, Chicago, Ill.

National Association of Broadcasters. 27th annual convention. April 6–12, 1949, Hotel Stevens, Chicago, Ill.

National Association of Corrosion Engineers. Fifth annual conference and exhibition. April 11–14, 1949, Netherland-Plaza Hotel, Cincinnati, Ohio.

National District Heating Association. 40th annual meeting. May 24–27, 1949, The New Ocean House, Swampscott, Mass.

National Electrical Manufacturers Association. Winter convention. March 13–18, 1949, Edgewater Beach Hotel, Chicago, Ill.

National Electrical Wholesalers Association. May 2–6, 1949, Netherland-Plaza Hotel, Cincinnati, Ohio.

National Fire Protection Association. May 16–19 1949, Fairmont Hotel, San Francisco, Calif.

Ohio Welding Conference. 10th meeting. April 7–8, 1949, Ohio State University, Columbus, Ohio.

Southern Machinery and Metals Exposition. 4th meeting. April 25–28, 1949, Municipal Auditorium, Atlanta, Ga.

Third International Lighting Exposition and Conference. Week of March 28, 1949, Hotel Stevens, Chicago, Ill.

NYU Engineer Students' Starting Pay Increases

Starting salaries for graduates of the New York University college of engineering increased in 1948 by 11 per cent over the previous year according to the results of a recently concluded survey. The results of the survey were compiled through questionnaires sent last fall to 365 graduates of the college of engineering, class of June 1948. The graduates were asked the nature of the position they held, how it was obtained, and the starting salary.

The average starting salary, it was revealed, was $252 a month, an increase of $25 over the 1947 average. The largest starting salary increase—16 per cent—appeared to be in the aeronautical and administrative engineering fields, the survey reported. Electrical engineering students showed an increase of 5.5 per cent, with an average salary of $251 per month.

Of the 177 graduates who returned their questionnaires, 72 per cent took jobs in private industry, 16 per cent went into civil service posts, 9 per cent enrolled for graduate courses, and 3 per cent were classified as miscellaneous. This distribution is about the same as in 1947. Sixty per cent of the former students who responded found jobs outside of New York. In 1947, 61 per cent obtained positions in the metropolitan New York area. About 70 per cent of the replies were from graduates who had secured jobs with the so-called "big" companies.

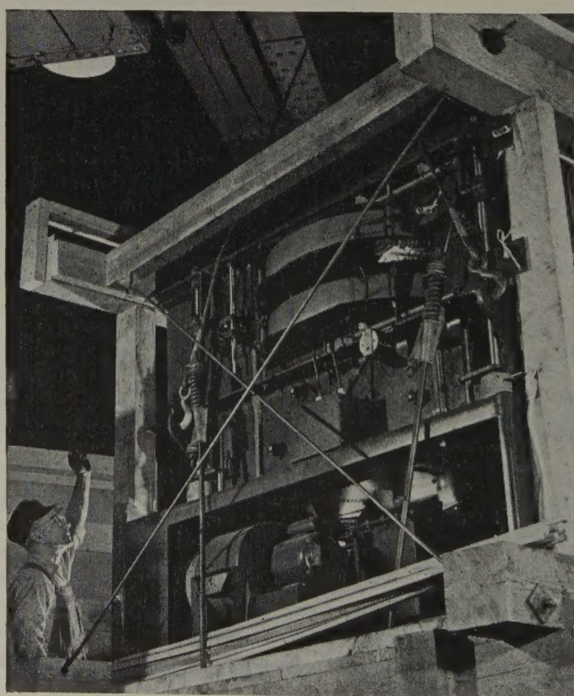
New State of India Plans Industrialization

India will spend approximately $60,000,000 in the United States for electric machinery in 1949, 1950, and 1951 in a vast program of industrialization, which should make that country America's best customer less than two years after gaining its independence. Part of India's industrialization program is the construction of several huge hydroelectric projects which will be used to reduce the cost of power for industry and also serve to increase India's useful acreage.

India's total expenditures in the United States during the 3-year period will total about a half billion dollars, mostly for capital goods. A report shows that India has the dollars with which to make purchases in the United States. Other products to be purchased by India in the United States include railroad equipment, trucks, ships, machine tools, office machinery, iron and steel manufacturing plants, and so forth.

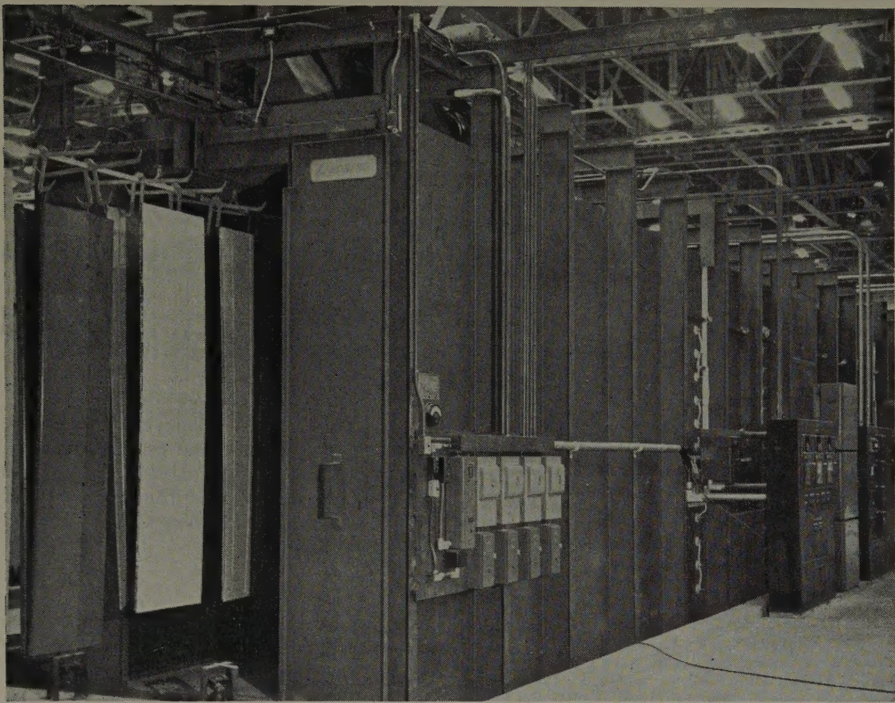
To encourage the industrialization program, the Government of India has drastically reduced the import duty on plant

Betatron for Cancer Research



Readied for shipment to the College of Medicine, University of Illinois, is this 22,000,000-volt betatron, first to be used for cancer treatment and research. Built by Allis-Chalmers, the only concern which has standardized production of this type, this betatron weighs five and one-half tons, is 36 inches wide, and 81 inches long, and comes equipped with capacitor bank and control panel

World's Largest Enameling Furnaces



The two largest electric enameling furnaces in the world are being used by Lustron Corporation, Columbus, Ohio, in producing porcelain enamel steel homes. The furnaces are 180 feet long and have an inside clearance of 11 feet. Working together, they can process 58,000 pounds of porcelain-coated panels an hour. It was necessary for the company to build a substation and install a 15,000-kva transformer to get the necessary power for running the plant

machinery and new industry has been given many income tax concessions. India recently signed with the United States an agreement for mutual reduction of import tariffs on a wide margin of articles which figure in the import trade of the two countries.

Tau Beta Pi Fellowships. Tau Beta Pi, engineering honor society, has announced its 16th annual program of fellowships for graduate study in engineering during the school year 1949–50. Amount of each fellowship, for which only Tau Beta Pi members are eligible, is for $1,200, payable in ten monthly installments. For additional information and application forms, write to Paul H. Robbins, Director of Fellowships, 1121 Fifteenth Street, N. W., Washington, D. C.

ASCE Elects 1949 Slate. The American Society of Civil Engineers, by mail ballot, elected Franklin Thomas, professor of civil engineering and dean of students, California Institute of Technology, Pasadena, Calif., as its president for 1949. New vice-presidents are Henry J. Sherman, Camden, N. J., and Robert B. Brooks, St. Louis, Mo., both consulting engineers. Six new members of the board of directors also were chosen. The officers were installed at the society's 96th annual meeting, January 19, 1949, in New York, N. Y.

Executives to Compete for Fellowships. Ten young executives from various fields of business will be chosen in a national competition for a year of graduate study in the Sloan Fellowship Program for Executive Development at the Massachusetts Institute of Technology. Award of the fellowships is made possible by a grant from the Alfred P. Sloan Foundation, Inc., and marks the resumption of the program which started in 1931, but had recessed during the war years. The awards carried stipends up to $4,000 for married men and $3,000 for single men. Recipients will be on leave of absence from their employers and will be in residence at the Institute from June 10, 1949, to June 15, 1950. Further information can be obtained from Professor Gerald B. Tallman, Department of Business and Engineering Administration, Massachussetts Institute of Technology, Cambridge, Mass., who is director of the Sloan program.

Air Force Wants Engineers. The Air Materiel Command, United States Air Force, Dayton, Ohio, can utilize the services of qualified professional personnel. Vacancies exist or are anticipated in the following positions: aeronautical engineer (aircraft production); production engineer (aeronautical equipment); radio engineer; ceramic engineer. Salaries range from $3,727 to $5,232 per year, with duty at Wright-Patterson Air Force Base, Dayton, Ohio. Application blanks and information sheets containing qualifications may be obtained at any first or second class post office. All communications should be directed to Headquarters, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio. Attention of: MCACXC32, H. W. Hoover.

Jet Propulsion Fellowships. Six $2,000 fellowships have been offered to qualified applicants by the Daniel and Florence Guggenheim Jet Propulsion Centers at Princeton University, Princeton, N. J., and the California Institute of Technology, Pasadena, Calif. College graduates, with suitable engineering or scientific background, outstanding technical ability, deep interest in rockets and jet propulsion, and demonstrated leadership qualities, are eligible to apply for the two years of postgraduate work in this field. Applications now are being accepted for the fellowships beginning in the fall of 1949. Further information and application blanks are obtainable from the Daniel and Florence Guggenheim Foundation, 120 Broadway, New York 5, N. Y.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Reverse Blowout Effect

To the Editor:

Concerning the reference made to "The Reverse Blowout Effect" by Gary J. Himler and George I. Cohn (*EE, Dec '48, pp 1148–52*), it may be of interest to mention that a similar effect as that observed by these authors, in the behavior of d-c arcs with high altitudes were utilized by the writer on the cathode of mercury arc rectifiers.

It was necessary to protect the ignition device from two close a neighborhood of the cathode spots. Magnets with a magnetic field, parallel to the surface of the cathode, had to be provided in such a way that a metallic conductor instead of the arc would have been moved towards the part to be protected.

H. C. BERTELE

(Research manager, Nevelin Electric Company Ltd., Croydon, Surrey, England)

Magnetization Fluxes

To the Editor:

The questions raised by F. W. Smith in his letter to the editor (*EE, Nov '48, p 1127*) interested me particularly, as they concern a phenomenon. I happen to have studied rather closely at the Swiss Federal Institute of Technology, Zurich. The results were published in 1941 under the title of "Pendelmagnetismus" ("Pendulum Magnetization" = superposed longitudinal nonalternating and crossed alternating magnetization fluxes) as thesis number 1194. A copy is available at the Georgia Institute of Technology, but the following summary of the results may be of some general interest.

With d-c cross-magnetization, the longitudinal magnetization curves show a fundamentally different form from those with ordinary assymmetrical magnetization when the direction of d-c magnetic field is parallel.

The iron and hysteresis losses are also of a different shape with pendulum magnetization than with linear assymmetrical magnetization.

Distortion of the magnetizing current at higher flux densities becomes less pronounced with Pendulum magnetization than with linear assymmetrical magnetization.

The form of the magnetizing curves with various forms of premagnetization shows that the conditions which are valid for ordinary magnetizing curves are also valid in the case of linear assymmetrical magnetization, but not when the resulting magnetic flux shows a displacement or oscillation.

When only part of a body is magnetized in several directions, the same phenomenon can be observed, though to a smaller extent than in the case of a hollow toroidal ring where every part is subject to longitudinal and cross magnetic fields.

The results obtained theoretically have been applied to the design of an inductance coil.

With cross-magnetization, a higher magnetic field is required than with longitudinal field if the same change of impedance is to be obtained.

At radio frequencies the pendulum magnetization appears to possess certain advantages.

Magnetic d-c amplifiers for metering purposes have a smaller hysteresis error with cross-premagnetization than with longitudinal premagnetization.

WALTER BOESCH

(81 Milchbuckstr. Zurich 5F Switzerland.)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

FUNDAMENTALS OF ELECTRIC WAVES. By H. H. Skilling. Second edition. John Wiley and Sons, Inc., New York, N. Y.; Chapman and Hall, Ltd., London, England, 1948. 245 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $4. Translating abstract wave theories into clear physical pictures using a minimum of mathematics, this book is an up-to-date presentation of electrostatics and electromagnetics. Among the changes in this edition are additional information on cylindrical and rectangular wave guides, reflection of waves from both conducting and dielectric surfaces, antennas, and wave propagation in semiconducting media and in ionized regions.

GENERAL ELECTRICAL ENGINEERING. Edited by P. Kemp. Odhams Press Limited, Long Acre, London, W. C. 2, England, 1948. 448 pages, illustrations, diagrams, charts, tables, 9 by 6 inches, fabrikoid, 9s.6d. The material covered by this elementary manual extends from basic theory to the design and use of high-power apparatus. Generation and distribution of electricity are considered as well as applications to all forms of communication and industrial processes. A brief guide to engineering drawing and an explanation of electrical terms, units, symbols, and formulas are given in the appendix. Each of the ten chapters is written by a specialist in the field.

INTRODUCTION TO APPLIED MATHEMATICS. By F. D. Murnaghan. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1948. 389 pages, diagrams, tables $9^1/_4$ by $5^3/_4$ inches, $5. Designed for graduate students and scientific workers with diversified interest, this book is a detailed and self-contained study of the mathematics used in modern physics and engineering. A methodical account is given of vector and matrix calculus, harmonic analysis, spherical harmonics, and Bessel functions. Also discussed are boundary value problems and integral equations, mechanical problems by means of the calculus of variations, and operational calculus.

MACHINE DESIGN. By Ph. H. Black. McGraw-Hill Book Company, New York, N. Y., Toronto, Ontario, Canada, and London, England, 1948. 357 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $4. Intended as a textbook for courses in general machine design, this volume also serves as a reference manual of established modern practice. Among the special features of the book are the following: surface finish, friction, and wear considerations; selection of vibration-absorbing units; allowable stress determinations; consideration of stress concentration in machine members, its applicability, seriousness, mitigation, determination, and design application. Fastenings and power-transmission units also are covered.

PERSONNEL ADMINISTRATION. By P. Pigors, and C. A. Myers. McGraw-Hill Book Company, New York, N. Y., and London, England, 1947. 553 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $4.50. Emphasizing a new approach, this basic text stresses the philosophy of personnel administration rather than giving a detailed analysis of systems and procedures. Part 1 is divided into six sections: the nature of personnel administration; handling personnel problems; diagnosing organizational stability; building and maintaining work teams; wages and hours; and employee services and programs. Part 2 gives case material to illustrate the subject matter in the preceding sections.

PRINCIPLES AND METHODS OF TELEMETERING. By P. A. Borden, G. M. Thynell. Reinhold Publishing Corporation, New York, N. Y., 1948. 230 pages, illustration, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $4.50. Discussing the various types of telemetering systems, this book also considers the instruments used in America today. In addition to the principles and applications, it gives an analytical and descriptive treatment of the large variety of telemetering devices produced by 17 companies. The bibliography covers both papers and patents.

PRINCIPLES OF MICROWAVE CIRCUITS. (Massachusetts Institute of Technology Radiation Laboratory Series, volume 8.) Edited by C. G. Montgomery, R. H. Dicke, and E. M. Purcell. McGraw-Hill Book Company, New York, N. Y., Toronto, Ontario, Canada, London, England, 1948. 486 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $6. Starting from Maxwell's equations, this book gives a description of guided electromagnetic waves. The concept of impedance is generalized to apply to waveguide circuits. Following a review of low-frequency network theory, general network theorems which apply both to high- and low-frequency circuits are developed. The properties of waveguide circuit elements are discussed fully. These general properties are applied to the discussion of microwave devices. The results which follow from the symmetry properties of microwave functions are emphasized.

MECHANICS OF MATERIALS. By G. Murphy. Irwin-Farnham Publishing Company, Chicago, Ill., 1948. 310 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $4.50. To develop the student's understanding of the behavior under load of structural members and machine parts, this book emphasizes principles, considers standard procedures of analysis, and provides indications that our knowledge of materials as constantly growing. The principles of statics, the characteristics of the geometry of the loaded member, and the effects of the properties of the material are stressed.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

1948 Cement and Concrete Reference Book. 88-page booklet on the history, manufacture, and uses of portland cement and concrete. Available from the Portland Cement Association, 33 West Grand Avenue, Chicago 10, Ill.

English Pamphlets. "Notes on Soldering," a review of researches and a compilation of facts of value to solder users in industry. Obtainable free of charge from Doctor Bruce Gonser, Battelle Memorial Institute, Columbus 1, Ohio. "The Influence of the Surface Structure of Individual Powder Particles in the Production of Powder Metal Components," published by and obtainable from Murex Ltd., Rainham, Essex, England.

FM Telemetering Transmitters. A four page folder with photos and circuit diagrams, plus construction details and ratings. Ten cents per copy from V. W. Palen, Bureau of Public Information, New York University, New York 3, N. Y.

The Diamond Research Laboratory. The history, methods of research, and current projects of the Diamond Research Laboratory of South Africa. Illustrated throughout. Obtainable from the Diamond Research Department, Industrial Diamond Information Bureau, 82/34 Holborn Viaduct, London, E.C.1, England.

Power in New England. A report of the Power Survey Committee of the New England Council, complete with color maps, graphs, and tables. $1.00 per copy from the New England Council, Stalet Building, Boston 16, Mass.

The Oscillographer, Vol. 10, No. 4. On the continuous-motion and/or single-frame oscillograph-record camera, and describing the camera, films, papers, processing techniques, and applications. Obtainable from Instrument Division. A. B. DuMont Laboratories, Inc., 1000 Main Avenue, Clifton, N. J.

Basic Radio Propagation Predictions for March 1949, three months in advance, CRPL Series D, Number 52. A National Bureau of Standards publication. 10 cents per copy, from the Superintendent of Documents, United States Government Printing Office, Washington 25, D. C.